Modern Dairy Cattle Management

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PREFACE

Modern Dairy Cattle Management is designed to present the fundamental aspects of the dairy industry, and the most effective techniques of feeding and management of dairy cattle, as established by research information Nutritive requirements, physiological functions and economic factors are covered in sufficient detail to provide a sound basis for the management practices which are recommended in each of these areas

Drastic changes in the management of dairy cattle will be necessary as adaptations are made for increased efficiency in food production to supply our expanding population The basic information provided in this book is intended to serve as a foundation on which sound management decisions may be made by the practicing dairyman, and a clear understanding of current practices and problems developed by the student

Milk secretion and the factors affecting it are given a prominent location early in the book, since this is the primary function of the dairy cow The chapters which follow include information on the effect of the many aspects of management, housing, and disease upon milk production, and upon the growth and development of dairy cattle The purebred business, which is an important aspect of the dairy industry, is also given consideration

The chapter on marketing is considered important because, while it is not a factor of management, an understanding of marketing conditions is an essential part of any production enterprise

The references given at the end of each chapter are intended as an entry into the literature which may be perused further by those interested They list recent or particularly important papers concerning the subjects involved Questions on each chapter, included at the end of the book, may be useful as an aid to study or instruction

Thanks are expressed to all the people who have made helpful suggestions concerning this work

Appreciation is due John A Sims for his constructive comments and reading of the manuscript The assistance given by Dr Norman L Jacobson and Dr A E Freeman in reviewing parts of the manuscript is appreciated

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1 Dairy Cattle in Modern Agriculture

DAIRYING is the largest single enterprise in American agriculture. Approximately 15 per cent of the gross income of our farmers is from the sale of milk. Dairy products also account for approximately 20 per cent of the food purchases made by the American housewife. With these purchases she obtains food of outstanding nutritional quality at a very economical price. Indeed, because of the excellent food value of milk and its products and their widespread use, the dairy cow has been called "the foster mother of the human race."

Producing milk is a dynamic and rapidly changing industry, presenting many challenges and opportunities to those engaged in it. The following background is provided as an aid to understanding the development and present position of dairying in our economy and society.

HISTORY OF DAIRYING

Cattle have played a key role throughout the development of western civilization. An entire book could be devoted to the interesting story of the part they have played in the past. A brief summary is presented here.

Early History to the Discovery of America

Dairy cattle were apparently domesticated and used by man long before recorded history. Drawings of cows and of men milking them have been found among the relics of civilization that grew up around the Mediterranean Sea as early as 3,000 years before Christ. Cattle were also an important part of the life of the Swiss Lake Dwellers, according to relics found in their ruins.

There are many references to cattle and to milk and its products in the Old Testament of the Bible. Cattle have been utilized for meat and milk, as well as for work animals, throughout the development of man. In Ancient Rome the keeping of cattle was a well-developed art, and one of our first type standards for dairy cattle is found in writings by Varro in the first century B.C., which were as follows: [Cows should be]

"well made, sound, long and deep bodied, with long horns, broad forehead, large black eyes, hairy ears, close set jaws, flat noses, with the back gently sloping downwards from broad high shoulders, wide nostrils, black muzzles, thick long necks, dewlaps hanging from the throat, a wide body well ribbed, a good rump, with tails hanging down to their heels and the lower parts well covered with hair, legs rather short, straight knees wide apart and large, the feet not broad nor sounding as they go, the two parts of the hoof not spreading far apart, the different hoofs of the same size and small, the hide not rough nor hard to touch. In color black is preferable, the next red, the third pale, and the fourth white."

While different from present concepts, the foregoing is as detailed as some of our current standards of excellence for dairy cattle.

Although cattle have been kept for centuries, it has been only in modern times that tremendous progress in developing the dairy industry has occurred.

The breeds which are predominant in America all originated in Europe and Great Britain. These cattle are referred to as *Bos typicus*, in contrast to *Bos indicus*, which is the name given the humped cattle of India and the Far East. A more detailed discussion of the origin of each of the breeds will be found in Chapter 12, "The Purebred Business."

At the time of the discovery of America, dairy cattle were an important part of the agriculture and life of the people in England and Western Europe.

Dairy Cattle in America

There were no cattle in North America when Columbus arrived in 1492. In many instances, the first settlers did not bring cattle with them, and cows were among the first and most urgent requests made by colonists to their home ports.

Most of the early imports were of mixed breeding. It was not until about the middle of the nineteenth century that the cattle which were the foundation of our present-day breeds were brought to this country and maintained as purebreds. Throughout the colonial period and until past the middle of the nineteenth century, dairying was limited to relatively small herds cared for by family labor. Management practices were at a level which we would consider poor today. The perishable nature of milk and the difficulty in transporting it made large-scale dairy operations impractical.

Probably the first examples of accumulating milk for manufacturing purposes were the co-operative efforts of neighboring farm families in pooling milk to make cheese. This was brought about by the relatively large amount of milk required in making satisfactory cheddar-type

cheese. For many years, butter making was done on the farm where the milk was produced.

Starting shortly after 1850, there were a number of significant developments and inventions which made possible the dairy industry as we know it today. These include the development of condensed milk by Borden, in 1856, the invention of the centrifugal cream separator, in 1878, the development of the Babcock test for fat, and the adaptation of pasteurization to milk. Mechanical refrigeration, homogenization, and modern packaging and transportation were also important.

MILK PRODUCTION IN THE UNITED STATES

A study of the number of cows kept for milk, and their production, over the last several years reveals interesting trends. Some of these are shown in Figures 1.1, 1.2, and 1.3. The number of milk cows reached a peak of nearly 26 million in 1944, near the end of World War II. Since that time there has been a constant decline, to just over 19 million in 1960. Early in this period of declining cow population there was also a decline in total milk production, reflecting a decreased demand following World War II. Starting in 1952, however, there was a consistent increase in total milk production, which leveled off and showed a slight drop in 1959-1960 with production at about 124,500,000,000 pounds.

Probably the most significant trend, as far as the future of the industry is concerned, is the consistent increase in average production per cow since 1935, as indicated in Figure 1.3. All present indications point *to a continuation of this trend.*

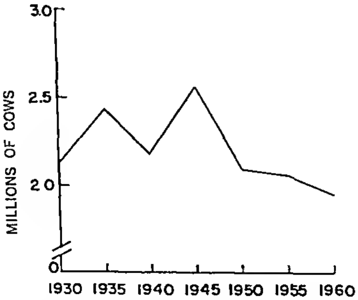


Figure 1.1. Numbers of producing dairy cows owned in the United States in June of selected years

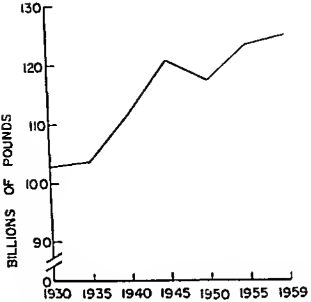


Figure 1.2. Trends in total milk production in the United States.

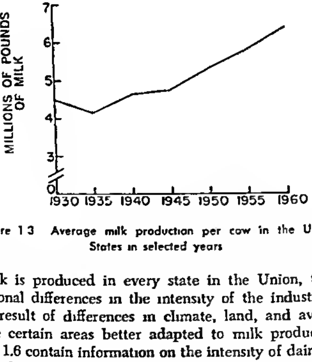
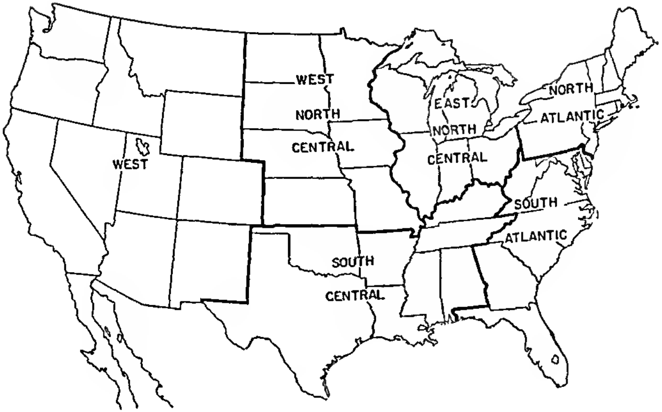


Figure 1 3 Average milk production per cow in the United States in selected years

While milk is produced in every state in the Union, there are important regional differences in the intensity of the industry. These are largely the result of differences in climate, land, and available feeds, which make certain areas better adapted to milk production. Figures 1.4, 1.5, and 1.6 contain information on the intensity of dairying in different regions of the country.

In addition to climate, land, and feed, population centers providing a large market have been a factor in determining the intensity of dairy-



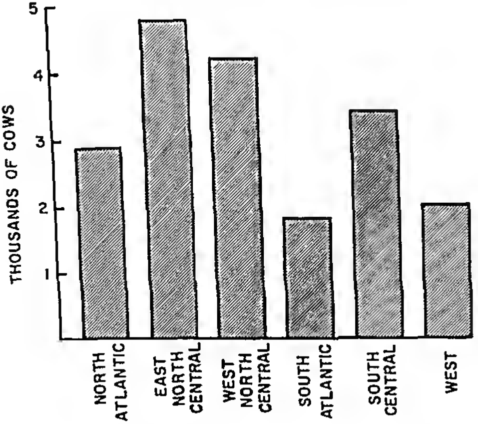
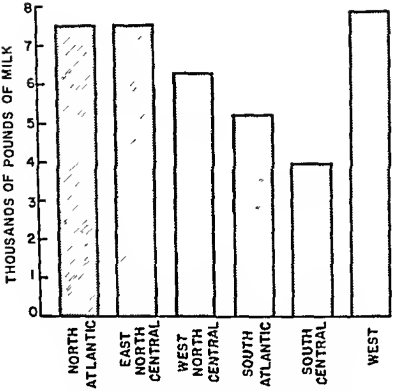


Figure 1.4. Numbers of producing cows in the United States by region (1960).



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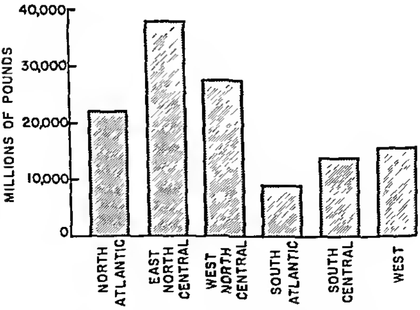

Figure 1.6. Milk production by regions in the United States.

ing in different areas. There has been much more intensive dairying in the northern half of the country. Generally, dairy cattle perform better and require less special care in areas where there are few days warmer than 85° F. Certain areas have developed a very intensive dairy industry, with herds of several hundreds of cows, serving big population centers. For example, California and Florida are areas where this type of dairying exists.

There are states within the regions indicated where dairying is particularly important or intensive. The states with the most cows are Wisconsin, Minnesota, New York, Pennsylvania, and California. These states also lead in total milk production.

Some smaller states have an equally intensive dairy industry but, because of their size, do not have as large a total cow population. Intensity of dairy management, as indicated by average annual production per cow, shows a somewhat different pattern. The leading states in production per cow are California, New Jersey, Rhode Island, Wisconsin, and Massachusetts. Some of the factors responsible for the location of intensive areas of dairying are covered more fully in other sections of this book.

MILK AS A FOOD

American Food Habits Concerning Milk

Most people like milk. It is well accepted by people of all ages and is nearly indispensable in the diet of children. These facts combine to give milk a prominent place in the American diet. Indeed, approximately 30 per cent of the animal protein in our diet is from milk or other dairy products. Table 1.1 contains information on the consumption of dairy products in areas of the world.

TABLE 1.1. PER CAPITA CONSUMPTION OF DAIRY PRODUCTS IN SELECTED COUNTRIES.[a]

Country	*Consumption in fluid milk equivalent*[b] lbs	Country	Consumption in fluid milk equivalent[b] lbs
Ireland	1,534	Norway	899
New Zealand	1,428	Denmark	842
Finland	1,366	United Kingdom	764
Australia	1,023	France	721
Sweden	1,013	United States	707
Canada	1,012	Germany, Republic	704
Switzerland	980	Netherlands	668
Belgium	975	Austria	655

[a] From, *Dairy Producer Highlights*, National Milk Producers Federation, 1959
[b] In 1956

In this country there has been a trend toward a smaller consumption of dairy products per capita. Most of this decrease is accounted for by the amount of butter eaten. We are consuming nearly 700 pounds of milk, or the equivalent, per person each year. The consumption of cheese and dry non-fat milk is increasing, while the use of evaporated milk is on the wane.

Tremendous challenges are presented to the dairy industry by the competition of other foods for a place in the American diet. The possibilities for increasing consumption of dairy products are indicated by the amounts eaten by people in some countries, as shown in Table 1.1.

Nutrient Content of Milk

It has been recognized for many years that milk supplies many of the high-quality nutrients needed by man. Energy, protein, fat, minerals, and vitamins, all essential in our diet, are abundant in milk.

A quart of milk of average composition will provide the amounts and percentages of the recommended allowances shown in Table 1.2. The National Research Council recommends the amounts of selected nutrients listed in Table 1.3 for the daily allowance of human beings.

The outstanding nutrient contributions in milk are its protein and minerals. Many of the specific basic units of protein (amino acids) must

TABLE 1.2.[a] NUTRIENT CONTENT OF ONE QUART OF MILK AND PROPORTION OF DAILY RECOMMENDED ALLOWANCE[b] FOR AN AVERAGE 25-YEAR-OLD MAN.

Water	*Energy*		*Protein*		*Fat*	*Sugar*
Per Cent	Calories	Per Cent of Allow.	Gms	Per Cent of Allow.	(Gms.)	(Gms.)
87	660	20	36	50	40	48

Calcium		*Iron*		*Vitamin A*		*Thiamine*	
Gms.	Per Cent of Allow	Mg	Per Cent of Allow	I.U.	Per Cent of Allow.	Mg.	Per Cent of Allow
1	100+	0.4	0.5	1560	30	.32	20

Riboflavin		*Niacin*		*Ascorbic Acid*	
Mg.	Per Cent of Allow.	Mg.	Per Cent of Allow.	Mg.	Per Cent of Allow.
1.6	90	0.8	38	8	10

[a] Taken, or calculated from National Research Council Recommended Daily Dietary Allowance, Revised 1958, and "Nutrients in Common Foods," *Food*, The Yearbook of Agriculture, 1959

[b] Where percentage of allowance is not indicated, recommended allowances are not available.

TABLE 1.3. RECOMMENDED DAILY DIETARY ALLOWANCES IN THE UNITED STATES (ALLOWANCES ARE INTENDED FOR PERSONS NORMALLY ACTIVE IN A TEMPERATE CLIMATE.) (REVISED 1958[a])

	Age (Years)	Weight (Pounds)	Height (Inches)	Calories	Protein Gm.	Calcium Gm.	Iron Mg.	Vitamin A I.U.	Thiamine Mg.	Riboflavin Mg.	Niacin Mg.	Ascorbic acid Mg.	Vitamin D I.U.
Men	25	154	69	3,200	70	0.8	10	5,000	1.6	1 8	21	75	.
	45	154	69	3,000	70	.8	10	5,000	1.5	1.8	20	75	
	65	154	69	2,550	70	.8	10	5,000	1.3	1.8	18	75	
Women	25	128	64	2,300	58	.8	12	5,000	1.2	1.5	17	70	. .
	45	128	64	2,200	58	.8	12	5,000	1.1	1.5	17	70	
	05	128	64	1,800	58	8	12	5,000	1.0	1.5	17	70	. .
Pregnant (second half)				+300	+20	1.5	15	0,000	1.3	2 0	+3	100	400
Lactating (28 ounces daily)				±1,000	+40	2.0	15	8,000	1.7	2 5	+2	150	400
Infants (age in months)	2-0	13	24	lb.x54.5	(b)	.6	5	1,500	.4	.5	6	30	400
	7-12	20	28	lb.x45.4	(b)	.8	7	1,500	.5	.8	7	30	400
Children	1-3	27	34	1,300	40	1.0	7	2,000	.7	1.0	8	35	400
	4-6	40	43	1,700	50	1.0	8	2,500	.9	1.3	11	50	400
	7-9	60	51	2,100	60	1.0	10	3,500	1.1	1.5	14	60	400
	10-12	79	57	2,500	70	1.2	12	4,500	1.3	1.8	17	75	400
Boys	13-15	108	64	3,100	85	1.4	15	5,000	1.0	2.1	21	90	400
	10-19	139	69	3,600	100	1.4	15	5,000	1.8	2.5	25	100	400
Girls	13-15	108	63	2,600	80	1.3	15	5,000	1.3	2.0	17	80	400
	16-19	120	64	2,400	75	1.3	15	5,000	1.2	1.9	16	80	400

[a] From: Food and Nutrition Board, National Academy of Science, National Research Council. *Foods,* The Yearbook of Agriculture, 1959.

[b] Allowances are not given for protein during infancy, but intakes of 1.5 grams of protein for each pound of body weight are ample for healthy infants.

be supplied in the diet of man While they are available in vegetable proteins, several different sources are usually needed to provide them in the proper proportions Milk and other animal proteins (such as eggs and meat) are the best sources of balanced protein

Not only is the protein of milk and by products highly adapted to human nutrition, but protein from milk is usually cheaper than from other sources Cottage cheese and non fat dry milk are the least expensive sources of animal protein available to us

Calcium and phosphorus are important for the growth and maintenance of bones and teeth as well as for proper body metabolism Milk supplies these minerals in generous quantities in the most desirable proportion and in a form readily available to the body

Normal milk from cows that have received adequate amounts of carotene (Vitamin A) can supply most of this nutrient Vitamin D is frequently added to milk in the processing plant Since vitamin C soon disappears from milk in usual handling procedures, it must be supplied from other sources Some minerals including iron and copper, are needed, particularly during growth in amounts greater than those found in milk.

The by products of milk contain different fractions of the nutrients of the original product Table 1 4 contains information on the nutrient contributions of all the usual items made from milk.

Feeding Our Growing Population

The problem of greatest concern to those who must plan for the future is our rapidly expanding population Medical science has made possible a much greater average life span The present rate of population growth is greater than at any time in history There is no indication that it will slow down in the foreseeable future Many times it has been predicted that man s need for food will increase much faster than his ability to produce it, and that starvation will limit the population While this appears to be a problem in some areas food production in the "Western" world has kept ahead of population demands How long this will continue is unknown

If full use is made of present technology, a much higher rate of food production can be achieved. New technology is being developed at a rapid rate and it appears that our food supplies will be adequate for many years However, we have reached the point where land available for food production can no longer be greatly expanded We may reasonably ask where does dairying fit in such a picture?

BASIS FOR A CONTINUING DAIRY INDUSTRY

There are large land areas in the United States which will produce abundant crops of forages but are poorly adapted for grains or other foods that man can use directly Dairy cattle and other ruminants have the ability to utilize these roughage materials and to convert them to high quality human food A large and increasing portion of research in animal agriculture is devoted to increasing the efficiency of utilization of forages by ruminants

Milk production is one of the most efficient processes we have in converting plant materials into animal food products for humans Since it will always be highly important to provide a palatable, well balanced diet for our population, it appears that dairy products will continue to make up a large portion of our food for some time to come We can, however, expect drastic changes from present practices in dairy management, and we must be ready to develop the most efficient production programs possible, based upon the physiology of the dairy cow

New and Useful Dairy Products

Perhaps the most difficult problem in handling and processing dairy products is their highly perishable nature Many of the products developed have resulted from attempts to prolong storage life Evaporated milk, condensed milk, milk powder, and cheeses all have a prolonged storage life Intensive research attempts are being made to provide products with the characteristics of fresh milk but with a longer storage life Sterile milk and concentrated milks are receiving the most attention Undoubtedly we shall see the development of one or more of these products as a major factor in our marketing system Lower transportation costs, as well as longer storage life, will be an advantage of these products

Dairy Cattle as a Source of Meat

In addition to milk, the dairy industry supplies approximately 35 per cent of the beef consumed in this country This takes the form of veal and cull dairy cows and bulls, as well as limited numbers of well fed heifers and steers Much of the meat from older animals finds its way into manufactured products The demand for processed meats has increased tremendously in recent years, with a narrower spread in price between good quality beef breeds and cull dairy cows New methods of handling and processing meats have contributed to this demand It appears that further advances in meat-processing techniques will en-

TABLE 1.4. NUTRITIVE CONTENT OF DAIRY

Food	Amount	Water (Per Cent)	Energy (Calories)	Protein (Grams)	Fat (Grams)	Sugar (Grams)
Skim milk	1 qt.	90	360	36	Trace	52
Buttermilk	1 qt.	90	360	30	Trace	52
Evaporated (undiluted)	1 cup	74	345	18	20	24
Condensed Sweetened (undiluted)	1 cup	20	985	25	25	170
Dry Whole	1 cup	2	515	27	28	39
Dry non-fat	1 cup	3	290	29	1	42
Half and half	1 cup	80	330	8	29	11
Cheese						
Cheddar or American	1 oz.	36	115	7	9	1
Cottage, Skim milk	1 oz.	79	25	5	Trace	1
Creamed	1 oz.	78	30	4	1	1
Ice Cream	⅐ qt.	62	165	3	10	17
Ice Milk	1 cup	67	285	9	10	42
Butter	1 tsp.	16	100	Trace	11	Trace

[a] From *Foods*, The Yearbook of Agriculture, 1959

[b] Year-round average.

hance the usefulness of meat from dairy animals. The potential for feeding and fattening cull dairy bulls or steers for meat is just beginning to be studied.

All of the factors mentioned in this section indicate that the dairy industry will have an important place in our economy for a long time to come.

ECONOMIC STATUS OF THE DAIRY INDUSTRY

A high capital investment is required for milk production. In the heavily populated areas of the country, if most of the feed is grown on the farm, the investment may be as high as $2,000 per cow. In addition, a high degree of training and skill is necessary for the management of a successful dairy operation These factors combine to make dairying one of the most stable of agricultural enterprises, since frequent or sudden moves into or out of dairying are difficult. Also, demand for milk and dairy products by consumers is rather constant, and this fact adds to the stability of dairying.

Excellent financial returns for management and labor are available from the dairy industry in units where there is efficient management. Because of the relatively high fixed costs involved, production levels must be maintained well above the present national average in order

PRODUCTS OTHER THAN MILK [a]

Calcium (Mg.)	Iron (Mg.)	Vitamin A (Value I.U.)	Thiamine (Mg.)	Riboflavin (Mg.)	Niacin (Mg.)	Ascorbic Acid (Mg.)
1,190	0.4	40	0.4	1.8	0.8	8
1,190	0.4	40	0.4	1.8	0.8	8
635	0.3	820	0.1	0.8	0.5	3
829	0.3	1,020	0.2	1.2	0.5	3
968	0 5	1,160	0.3	1.5	0.7	6
1,040	0.5	20	0.3	1.4	0.7	6
259	0.1	1,190	0.1	0.4	0.1	2
221	0.3	380	0.01	0.1	Trace	0
26	0.1	Trace	0.01	0.08	Trace	0
25	0.1	50		0 08	Trace	0
100	0 1	420	0.03	0.15	0.1	1
292	0.2	420	0.09	0.41	0.2	2
3	0.0	460 [b]	—	—	—	0

to provide a reasonable income. Under present conditions, an annual production per cow of approximately nine to ten thousand pounds of four per cent milk or its equivalent is required to pay all expenses of production. Production rates above this provide a substantial profit or management income.

The Pricing of Milk

In most markets in the United States, the price received by the producer for milk is determined to a large extent by the use made of it. Milk for direct consumption as fresh milk or cream brings the highest price. Milk utilized for manufacture of by-products brings varying proportions of the price paid for milk sold directly to the consumer. The subject of marketing milk and dairy products is too broad to attempt to cover fully here. It provides the content for an entire college course. Chapter 14 contains information on some of the principles and practices involved.

MANAGEMENT FACTORS IN DAIRYING

As is true in most enterprises, careful attention to efficient management is essential to success in dairying. Of particular importance in successful dairy management are effective use of labor and maintenance of

efficient levels of production The latter requires careful attention to the principles of breeding, feeding, herd health, and herd supervision

Several of these subjects are covered in detail in subsequent chapters A summary is presented here

Labor Efficiency in Dairying

Modern labor-saving devices, which will be discussed more thoroughly under housing, make it feasible for one man to care for 40 or more cows The importance of well trained men with a direct interest in cattle cannot be overemphasized The individuality in response of different cows to routine management conditions makes it necessary to have men in the dairy who can correctly interpret these responses and make appropriate adjustments

Undoubtedly there will continue to be increasing specialization in the labor force involved in milk production Indeed, in some areas of the country, men are employed specifically as milkers, and may serve one or several herds

In addition to caring for a reasonable number of cows, each full time man should be expected to be responsible for the production of 400,000 pounds of four per cent milk or its equivalent per year

Efficient Production Levels per Cow

A minimum goal of 10,000 pounds of four per cent milk or its equivalent is desirable for an effective dairy operation The more profitable enterprises have production levels considerably higher than this While average production is much below this (Figure 1.3), continued profitable operation is doubtful at a lower figure Average production has increased at a remarkable rate, as shown in Figure 1.3, and we may expect even faster advances in the future In 1958, the average production of all cows included in the standard dairy herd improvement program (DHIA) exceeded the 10,000 pound level for the first time There are a number of profitable, practically managed herds producing at 50 per cent above the DHIA average A continuation of the trend of increasing production can be expected This will be achieved through judicious management, taking full advantage of the best information available on feeding, breeding, milking practices, and general management, and good marketing practices

The successful dairyman of the future must be well trained in the basic sciences, business administration, animal physiology, and nutrition, and have the personality and ability to weld this knowledge into a smooth functioning, efficient production unit.

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2 Milk Secretion— Harvesting the Milk Crop

THEIR ability to produce large amounts of wholesome milk is the principal reason dairy cows are given a place of prominence in our economy. Therefore, the physiology involved in the production of milk and the factors affecting it are given rather extensive treatment in this book.

COMPOSITION OF MILK AND SOURCE OF CONSTITUENTS

Milk is composed of water, lipids (fatty material), protein, sugar, minerals, vitamins, enzymes, and some body cellular material. The average composition of cow's milk, in comparison with that of other species, is presented in Table 2.1. Differences between the milk of humans and cows are worthy of note. Cow's milk is frequently modified by the addition of sugar and slight dilution to more nearly approximate human milk for the feeding of babies.

TABLE 2.1. APPROXIMATE AVERAGE COMPOSITION OF THE MILK OF COWS, HUMANS AND GOATS.[a]

Component	Cow %	Human %	Goat %
Water	86.8	88.2	87.9
Total solids	13.2	11.8	12.1
Fat	3.7	3.7	3.9
Protein	3.2	1.3	3.2
Sugar	4.6	6.8	4.5
Ash	0.7	0.2	0.7

[a] Calculated from *The Composition of Milks* Publication 254, National Research Council. Revised 1953.

There is a great deal of variation in the composition of milk between different breeds of cows and between individual cows within breeds. Figures indicating the average composition of milk from each of the breeds are presented in Table 2.2. Variations in the composition of

milk may be inherited. The selection of animals which produce milk with specific characteristics is discussed in Chapter 7.

TABLE 2.2. APPROXIMATE COMPOSITION OF MILK OF THE FIVE MAJOR DAIRY BREEDS.

Breed	Fat %	Protein %	Solids not Fat %
Ayrshire	4.0	3.5	9.0
Brown Swiss	4.0	3.5	9.0
Guernsey	4.9	3.7	9.4
Holstein	3.6	3.2	8.7
Jersey	5.4	3.8	9.4

All of the constituents of milk come from the blood of the cow. Some are modified by the tissues of the mammary gland. Others appear in similar form in milk and in blood.

The water of milk acts as a carrier for other nutrients. Some of the nutrients are in solution in the water; others are in suspension, which accounts for the white, opaque appearance of milk. The water in milk is removed directly from the blood.

The protein of normal milk is composed of a number of different individual fractions. For our purposes, they may be divided into: (1) casein (approximately 80 per cent), composed of fractions called α, β, and γ casein, and possibly δ casein; (2) lactoglobulin (approximately 7-12 per cent); (3) a lactalbumin (approximately 2-5 per cent); (4) "blood" serum albumin (approximately 0.7-1.3 per cent); (5) immune globulins (approximately 0.8-1.7 per cent); and (6) pseudoglobulin (approximately 0.6-1.40 per cent). Casein is a protein found only in milk, in all species, and is a product of modification or synthesis by the cells of the mammary gland, using amino acids or protein fragments supplied by the blood. This fraction of milk protein is of major importance in the manufacture of cheese.

The immune globulins are of particular importance because they carry antibodies. They occur in greatly increased concentration in colostrum (the first secretion at the beginning of a lactation). The antibodies are essential to protect the newborn calf against a number of diseases. "Blood" serum albumin appears to be identical with a protein in bovine blood. It and the immune globulins apparently occur in milk by filtration from blood.

The lipids of milk contain true fat, phospholipids, cholesterol, pigments, and fat-soluble vitamins. The true fat molecule is composed of one molecule of glycerol combined with three molecules of various fatty acids. These fatty-acid molecules may contain from 2 to 20 or more carbon atoms. Some of the combinations of fatty acids in milk fat are characteristic of this substance and are not found in other

natural fats Fatty acids containing only a few carbon atoms (acetic, two propionic, three, and, particularly, butyric, four), as well as those with 7 to 10 carbon atoms, are especially characteristic of milk. The production of butterfat is a *synthetic process carried on* by the mammary tissues, utilizing the products of digestion and material which comes from the breakdown of body fats

Cholesterol is a substance which is converted to vitamin D when exposed to ultraviolet light It occurs in animal fats and has been a subject of much controversy in association with vascular (circulatory system) disease in humans Present evidence indicates that a number of factors other than cholesterol in the diet play an important role in this disorder

Fat soluble vitamin A is an important nutritive contribution of milk for human food This occurs in milk in proportion to the amounts present in the cow's body The nutritive state of the cow is therefore important in regard to this constituent The yellow color of milk is due to pigments which are precursors of vitamin A Cows which produce yellow milk only are poor converters of the pigment carotene to vitamin A In breeds which produce white milk this conversion is more complete There is no significant difference in the nutritive value of carotene or vitamin A for humans when adequate quantities of either are present in their diet

Vitamin E also is present in fresh milk in proportion to its presence in the diet of the cow

Fat in milk occurs as small globules separated from the other material by an extremely thin membrane This type of suspension is called an emulsion The production of butter by churning and the rising of cream are important properties of milk brought about by the characteristic behavior of the butterfat

The term *solids not fat* is frequently applied to the content of sugar, protein minerals, and other non fat components in milk

The sugar in milk is called *lactose* Lactose is found only in milk. It is a *disaccharide,* which means that it is made up of two simple sugar molecules or *monosaccharides* Its composition is only slightly different than that of sucrose, which is the sugar of common table use Galactose and glucose are the two simple sugars in lactose The sugar of milk is the result of an active synthetic process of conversion from blood glucose

Mineral matter in milk is made up of a number of different elements The principal elements are calcium and phosphorus All the minerals are incorporated into milk directly from the cow's blood supply, but some of them are tied up in special biological combinations in milk.

Vitamins are an important nutritive contribution of milk Vitamins A D and E have been mentioned under the lipids Milk is particularly high in riboflavin (vitamin B_2) and is a good source of other B vitamins

Vitamin C occurs in fresh milk but, under standard processing and distribution procedures, is usually destroyed before it is consumed. Water-soluble vitamins are incorporated unchanged into milk from the blood. Since they are synthesized by bacteria in the rumen of the cow, the level of B vitamins in milk is relatively constant.

A number of enzymes (substances which speed chemical reactions but do not enter into them) are found in milk. They are important for the effect they have on milk flavor during handling and storage. Certain lipases (enzymes which break down fats) can have an undesirable influence on milk flavor if their action is not controlled. Some tests for the completeness of pasteurization of milk are based upon the presence or absence of enzymes destroyed by pasteurization.

Body cells and cell fragments found in milk arise from the degeneration of secretory cells and the apparent passage of some white blood cells into the secreting area.

STRUCTURE OF THE UDDER

The mammary gland is a specialized development of skin tissue. It is located outside the body wall and maintains its association with the

Figure 2.1. The udder of an outstanding Ayrshire cow, Crusader's Joyce of Windy Top, at 19 years of age, after producing over 200,000 pounds of milk. Courtesy The Ayrshire Breeders Association

body by connective tissue supports, its covering of skin, and circulatory vessels and nerves which reach it through the *inguinal canal* or under the skin

In the cow the mammary gland, or udder, is composed of four separate complete units called *quarters* These are joined closely but divided by membranes so that there is no communication between them except through the blood stream and the central nervous system Figure 2 1 contains a picture of the udder of a high producing cow

The secretory portion of the udder consists of countless *alveoli* or tiny chambers lined with individual secretory cells Each of these alveoli is drained by a small duct which leads to larger ducts Clusters of alveoli resembling a bunch of grapes are drained by ducts of increasing size until some 10 to 20 ducts conduct milk into the gland cistern Figure 2.2 shows a cross section of a cow's udder with details of the secretory and *storage system* as well as the *structure* of the teat

Each alveolus is supplied blood through tiny capillaries which lie outside the secretory cells Small muscle fibers also surround each alveolus and are important in the removal of milk from the gland The individual secretory cell is the primary factor in milk production It extracts all of the components of milk from the blood stream and either arranges them into new compounds or passes them through directly into the alveolus

THE CIRCULATORY SYSTEM OF THE UDDER

The production of milk requires a rich supply of blood to the mammary gland The major blood vessels involved are the *external pudic arteries*, which are paired vessels each supplying one half of the udder These arise from major arteries supplying the rear portion of the cow and pass through the inguinal canal to reach the udder At the udder, numerous branches occur which provide blood to most of the gland Another artery which is of minor importance is the *perineal* Smaller and smaller arterial branches lead to tiny vessels called *capillaries* which surround the alveoli or secretory parts of the gland and supply nutrients to them

The capillaries form the junction between the small arteries and the small veins The veins unite to form larger and larger trunks which return the blood to the heart The principal veins involved are the *external pudics*, which run parallel to the external pudic artery

Figure 2.3 contains diagrams indicating the location of major blood vessels supplying the udder The abdominal veins ("mammary veins"), which lie on the under side of the abdomen, also carry blood from the udder Research has shown that the relative size of this blood vessel is

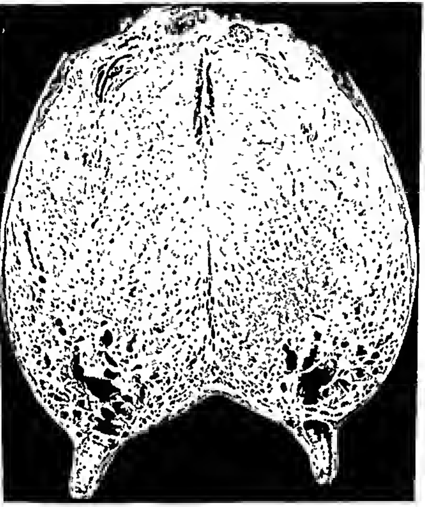

Figure 2.2. A cow's udder in cross section. Structures that may be observed include secretory tissue, ducts, gland cisterns, teat cisterns, streak canals, the median suspensory ligament, and fatty tissue and lymph nodes at the top of the udder. Courtesy W. W. Swett, Agricultural Research Service, U. S. Department of Agriculture.

not necessarily a good indicator of ability of the animal to produce milk. However, in many high producers these veins are prominent, well developed, and tortuous.

While not so dramatic or so easily observed as the blood stream, the lymphatic system is an important part of the circulation of animals. *Lymph* is the name given to the fluid outside of the arteries and veins which bathes all body cells. Many nutrients pass from the blood, through lymph, to the cells. The lymph system of the udder, with its lymph nodes, helps clear bacteria and undesirable material from the udder. The lymph system moves the fluid upward and toward the rear of the udder through the supramammary lymph nodes and through the system of lymph vessels which eventually empty into the blood stream in the chest region.

Udder *edema* or swelling, frequently a serious problem at calving

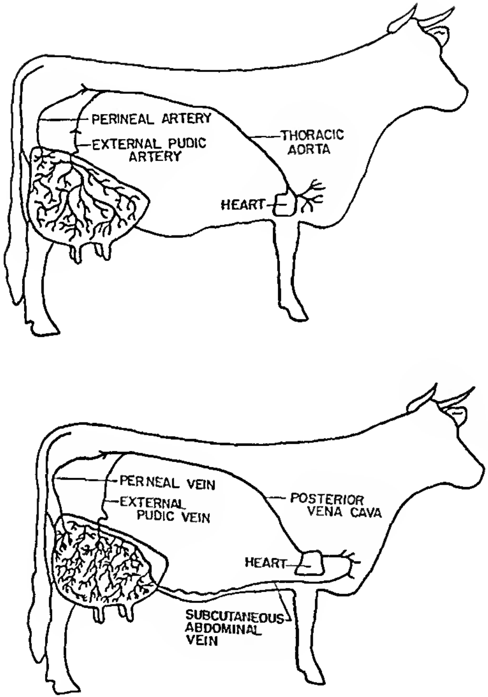

Figure 2.3 The blood circulation to the udder Arterial circulation is shown above venous circulation below

time, is a result of an inadequate rate of removal of lymph from the udder.

The nervous system. The udder is well supplied with nerves. These are important in the mechanism of milk "letdown" and in controlling circulation in the udder.

Udder supports. The attachment of the mammary gland to the body is important with the large udders of high-producing capacity which have been developed. Loosely attached or pendulous udders are frequently susceptible to injury or mastitis. The principal support and attachment of the udder are provided by the *median suspensory ligament,* which is located in the midline of the body.

This ligament is attached to the pelvic arch. If it is stretched or weakened, a pendulous udder results. Permanent stretching of this ligament results in turning out or "strutting" of the teats, making machine milking very difficult. Support is also provided by connective tissue located under the skin of the udder, referred to as the *lateral suspensory ligaments.* Connective tissue fibers run from the ligaments into the areas of secretory tissue to provide support to the udder. Figure 2.4 is a picture of a pendulous udder.

Figure 2.4. A pendulous udder. Note the dropped floor of the udder and the strutting teats, caused by the breakdown of the median suspensory ligament.

Structure of the teat. Figure 2.2 shows the major characteristics of the teat. It is a specialized structure for holding milk in the teat and udder cisterns and for facilitating the removal of milk from each quarter. The teat cistern makes up a major portion of it. The end of the teat contains an opening called the *streak canal.* The streak canal is closed by a sphincter or circular muscle at the end of the teat. The strength of

this muscle determines to a large degree the ease with which milk can be removed from the teat and the time and effort required in milking.

As noted in Figure 2.2, there is a fold of tissue at the top of the teat which partially separates the teat cistern from the gland cistern.

DEVELOPMENT OF THE UDDER

From a production point of view, the development of a satisfactory functional udder is as important as management of it after maturity.

Embryonic Development

Indications of the udder are visible as specialized structures early in the growth of the embryo. In mammals the fetus goes through a number of stages of evolution. In early development there is a line of primary tissue from which functional mammary glands may develop along each side of the abdomen. In some mammals, such as swine, a number of these develop into potentially functional glands. In other species, all but two or four normally disappear. While four is the usual number which persist in cattle, it is not unusual for one or more additional glands to occur. Frequently these are functional, although much reduced in producing capacity.

At birth the udder consists of the teats, teat cisterns, gland cisterns, and structures which will later develop to form the duct system. From birth to puberty little mammary change takes place. There may be some deposition of fatty tissue in the udder of well-fed animals.

After puberty there is some growth of the duct system with each recurrence of the estrus cycle. This growth has been shown to be stimulated by *estrogen*, a hormone secreted by the ovarian follicle. The finer ducts and the alveoli do not appear until the first pregnancy. The secretory tissue develops under the influence of another hormone, *progesterone*, from the *corpus luteum* of the ovary. A proper balance between these two hormones is apparently necessary for development of the udder. Hormones from other sources, including the placenta, are undoubtedly important in development of functional mammary tissue. Growth of the secretory tissue is thought to be well completed during the first two-thirds of pregnancy. However, since the secretory tissue is completely collapsed and there is normally a replacement of fatty tissue with secretory cells, there is little apparent enlargement of the udder until secretion of colostrum begins, a short time before birth of the calf.

INITIATION OF MILK SECRETION

A rather specific hormone balance which is not completely understood is apparently necessary for the commencement of lactation. A hormone called *lactogen*, secreted by the pituitary gland, appears essential for

this muscle determines to a large degree the ease with which milk can be removed from the teat and the time and effort required in milking.

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THE SECRETORY PROCESS

Previous discussion has indicated that milk secretion is the result of a combination of synthetic and filtration processes conducted by the cells lining each alveolus. Details of most of the specific mechanisms involved are not well understood. It is known that milk secretion is a continuous process and that it is reversible. Milk not removed from the udder is reabsorbed when external pressure on the alveolus equals 30 to 40 mm. of mercury. Prolonged failure to remove milk, or incomplete milking, causes a reduction in milk secretion and involution of the secretory tissue.

The rate and direction of the process are at least partially controlled by the relative pressure existing in the udder. Milk is apparently produced most rapidly immediately following milking As pressure builds in the udder, the rate is slowed until an equilibrium condition exists. If milk is not removed for a prolonged period, reabsorption occurs. This explains the fact that appreciably more milk may be obtained from high-producing cows milked three or four times a day compared to those milked twice a day.

Microscopic observations of alveolar cells in the active state indicate that there is an accumulation of secretory granules in the end of the cell toward the cavity of each alveolus. There is a change in shape of the secretory cells, which become distended and more rectangular in shape rather than cuboidal. Some researchers believe that there is an actual rupture of the cell wall, allowing the escape of milk particles. Some of the constituents may pass through the intact semipermeable cell membrane. The actual process of milk formation and expression from the secretory cell is a complicated process, and much remains to be learned about it.

Fat appears to be provided at a rate somewhat independent of the secretion of other milk solids. Several factors indicate this. Fat secretion may be more markedly affected by changes in internal pressure. Strippings, or the last portion of a given milking, are usually high in fat, perhaps as a result of release of pressure in the udder and consequent release of fat globules from the secretory cells during the milking process Also, in cases when there is a decrease in total production, there is frequently an increase in the fat percentage of the milk.

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lactation It has been observed in greater amounts following calving and it appears to be discharged more rapidly into the blood stream when a cow is milked There is a reduction in the amount present as lactation tapers off.

Other hormones are esssential for milk production The contributioos of estrogen and progesterone have been discussed Lack of hormones from the adrenal glands and the thyroid, and of hormones other than lactogen from the pituitary gland will inhibit or stop lactation

The Milk 'Letdown" Mechanism

When milk secretion has continued for a considerable period after milking the alveoli, ducts and gland and teat cisterns are filled with mdk Mdk in the cisterns and larger ducts can be removed readily Milk in the smaller ducts and alveoli does not flow out easily However, the cow and other mammals have developed a mechanism for releasing milk from the mammary gland Stimulation of the central nervous system by something associated with the milking process is necessary to initiate the reaction. Stimulation of nerve endings in the teats sensitive to touch pressure, or warmth is the usual mechanism The sucking action of the calf is ideal for this However massaging the udder or washing with warm water is the usual method employed Stimulation is carried by the nerves to the brain which is connected with the pituitary gland located at its base Mechanisms are activated in the pituitary gland which cause the hormone *oxytocin* to be released from its posterior lobe Oxytocin is carried by the blood stream to the udder, where it acts on the small muscle cells surrounding the alveoli causing them to contract The pressure thus created forces the milk out of the alveoli and smaller ducts as fast as it can be removed from the teat Figure 2.5 presents a diagram outlining the letdown reflex

A period of from 45 seconds to one and one half minutes is required from stimulation to first noticeable "letdown" of milk The effective time of the hormone is limited and milking should be completed within 8 minutes if all the milk is to be obtained

The mecbanism may also be triggered by sounds or activities whicb the animal learns to associate with the milking process, as well as by stimulation to the udder

The hormone *epinephrine*, which is released from the adrenal glands when an animal is angered or frightened, is believed to be antagonistic to this mechanism and to partially or completely block the "letdown" response The "letdown" mechanism provides a basis for many of the practices included in the section on recommended milking procedures whicb follows

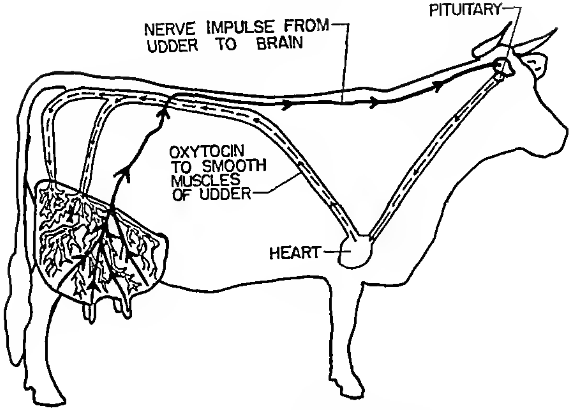


Figure 2.5. Diagram of the milk let-down reflex.

Removal of Milk From the Udder

The physical principles involved in removing milk from the udder must be understood if an effective job is to be done. Since this is the "harvest" to which all other dairy activities are pointed, it is important that it be done completely and in a manner which leaves the udder in optimum condition for future production.

In hand milking, the top of the teat cistern is closed off and pressure is applied to milk in the cistern, which is forced out through the streak canal. When pressure is released, the opening at the top of the teat cistern allows milk to flow into the cistern, and the process is repeated.

As is shown by the diagram in Figure 2.6, the principle by which milk is removed by machine is quite different. In machine milking, a continuous partial vacuum is maintained inside an inflatable rubber tube, the *teat cup liner*, and around the end of the teat. A partial vacuum alternating with normal atmospheric pressure is maintained between this tube (often called the *inflation*) and the wall of the teat cup. Milk flows from the teat during the time the vacuum is in effect. The vacuum pulls the inflation close to the teat cup wall, allowing the teat to expand. When there is normal air pressure between the inflation and the cup wall, the teat is compressed and massaged. This aids the blood flow and helps prevent congestion and irritation of the teat.

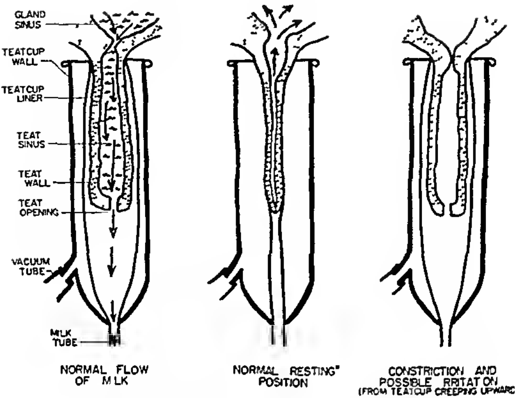


Figure 2 6 Mechanisms of removal of milk from the teat by a milking machine

Rapid Milking

It is important to complete the milking operation with dispatch As mentioned previously the "letdown" mechanism persists for only a few minutes Rapid milking tends to reduce the possibility of injury to the udder With careful attention most cows can be trained to milk-out in three or four minutes Many cows milk out in as little as two minutes Even high producers can be completely milked in this time Only a small percentage of cows will require over three or four minutes

A number of mechanical factors influence the rate and efficiency of milking including *vacuum level* the degree of vacuum attained in the teat cup *pulsation rate* the number of cycles of alternating vacuum and atmospheric pressure which occur in a minute and *pulsation ratio*, or the proportion of time spent under vacuum and atmospheric pressure Rate of milking is a result of interaction of all of these.

Vacuum levels of 5 to 8 pounds per square inch of negative pressure (10 to 16 inches of mercury) are usually recommended by milking machine manufacturers Rate of milking may be increased slightly with increased vacuum levels *However there is greater opportunity for*

creeping up of teat cups and damage to udder and teat tissues at higher vacuum levels. Ideally, negative pressure should be adequate to open the teat and cause milk to flow through the teat sphincter at a rate that is rapid but not sufficient to cause irritation or injury. Since there is tremendous variation between cows in the strength of the teat sphincter, a generally applicable figure is difficult to establish.

Pulsation rate. Milking machines of different manufacturers are known to have a wide range of recommended pulsation rates. These may vary from a high of 120 cycles per minute to as low as 40. Milk flow tends to be more rapid at the higher rates, with milk flowing a greater percentage of the time. Rapid pulsation rates are usually suggested for machines with bigger teat cup liners. Milking rate is affected more by high pulsation rates in machines which operate at low vacuum levels than in those with high vacuum levels.

Pulsation ratios. With cows which milk out rapidly, milk may flow continuously when the machine is attached, particularly during the earlier part of the milking process. In general, increasing the portion of time the liner is in the "expansion" phase, or under vacuum pressure, increases milking rate. A pulsation ratio of 60:40 causes milk to flow faster than one of 50:50. However, differences are not in direct proportion to the different ratios involved.

Pulsation ratio can also be called *expansion-collapse ratio*.

Adjusting the Individual Milking Machine

Since the performance of a given machine is the result of interaction of the factors mentioned above, all of them should be functioning properly for the most efficient milking. Milking machine manufacturers provide specific recommendations for the vacuum levels, pulsation rates, and pulsation ratios at which their machines work best. Frequent checking of each unit to see that it is functioning properly is important. One of the most frequent disorders is the failure to maintain the proper vacuum. Vacuum lines large enough to maintain recommended pressures at all points, when all machines are running, are important. Dirt or rust frequently accumulate in vacuum lines, reducing the vacuum existing at the stall cocks. Routine inspection and cleaning should be carried out.

The rate of milk flow from the teat is controlled to a large extent by the strength of the sphincter muscle. Variation between families and groups of cows in this characteristic is such that it is believed to be an inherited factor. Ease of milking is becoming a factor in selecting animals for breeding purposes. Surgical techniques are available for reducing the strength of the teat sphincter in cows which are difficult milkers, but they are seldom satisfactory.

SUGGESTED MILKING PROCEDURE

Maintain the cow in an environment with which she is familiar and at ease

1 Wash the udder with an individual cloth or paper towel dipped in warm water containing a satisfactory sanitizer Make sure the udder is clean

2 Remove one or two streams of milk from each quarter *on a strip* cup Make provision for discarding abnormal milk and preventing the spread of infection from infected quarters to healthy ones

3 Approximately one minute after stimulation of udder attach the milking machine

4 Observe the cow carefully When milk flow begins to stop "machine strip" the udder by pulling down on the teat cups and massaging the indivdual quarters to remove the last of the milk Care should be taken to prevent the situation indicated in the last sketch in Figure 2.6 where the teat cup creeps up on the udder and shuts off milk flow This occurs when most of the milk has been removed from the udder Not only is milk flow halted, but delicate tissues of the udder and teat may be injured providing an opportunity for infection

5 When milking is completed remove the teat cups gently, breaking the vacuum in each teat cup by inserting the finger

6 The milking machine should be cleaned and sanitized after each milking as discussed in Chapter 13 It should be assembled and adjusted according to the manufacturers specifications Poor adjustment of milking machines in regard to vacuum level or pulsation rate results in incomplete milking or prolonged milking time and may be a cause of udder injury

FACTORS AFFECTING THE TOTAL AMOUNT AND COMPOSITION OF MILK

A number of factors some of which may be partially or completely controlled by management practices have a definite effect on the amount of milk obtained or its composition

Stage of Lactation

Figure 2.7 contains a graph showing a typical lactation curve Immediately after calving milk production starts at a fairly high level The amount produced normally increases for approximately four to six weeks when the cow reaches her maximum production From this

point there is a gradual decline until the end of the lactation. For most efficient production, cows should reach a high peak of milk production and exhibit good *persistency*, or ability to maintain relatively high levels of production, throughout the entire lactation.

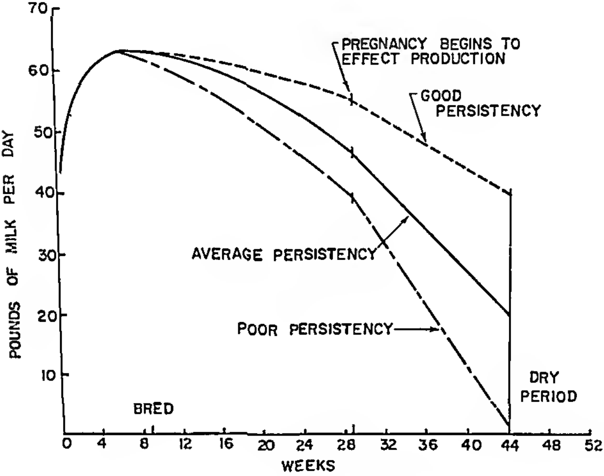


Figure 2.7. Typical variations in daily milk production during lactation.

The most striking change in the composition of milk associated with stages of lactation is the difference between *colostrum* and normal milk.

Colostrum is the first "milk" produced after parturition, when the animal has not been milked previous to one or two days before calving. Colostrum may have double the total solids of normal milk. The globulin fraction is increased to as much as 15 per cent. Lactose content is reduced. The vitamin A content may be as much as 20 times higher than normal. Table 2.3 contains data on the composition of colostrum at different times following parturition. Production of normal milk starts soon after parturition, and it is usually considered salable after about the sixth milking.

TABLE 2.3. AVERAGE COMPOSITION OF COLOSTRUM PRODUCED BY COWS AT VARIOUS TIME INTERVALS FOLLOWING CALVING.[a]

	Time after Calving						
Component	Hrs. 0	Hrs. 12	Hrs. 24	Hrs. 36	Hrs. 48	Hrs. 72	Days 5
Total solids	27.0	14.5	12.8	12.2	11.5	11.8	12.7
Fat	5.1	3.8	3.4	3.5	2.8	3.1	3.8
Protein	17.6	6.0	4.5	4.0	3.7	3.8	3.8
Sugar	2.2	3.7	4.0	4.0	4.0	4.7	4.8
Ash	1.0	0.9	0.9	0.8	0.8	0.8	0.8

[a] From: *The Composition of Milks.* National Research Council Publication 254. Revised 1953.

Modifications in fat percentage in milk occur with advancing lactation. There tends to be a drop in fat percentage for the first month or two. However, there is much individual variation, at least partially associated with the condition of the cow at calving time. At the end of lactation, it may be as much as 0.5 to 1.5 per cent higher than at the beginning. The size of fat globules in milk tends to decrease toward the end of lactation.

Some cows produce milk more susceptible to off-flavors as a result of oxidation in the final weeks of lactation.

Inheritance

Variation in the ability of indivdual cows to produce milk is an inherited characteristic. This applies to total milk, fat, and solids-not-fat. Length of period of high production or persistency, as well as total production, are influenced by heredity. Many factors are involved in establishing the inherited capacity for milk production. These include hormone levels and balance between different hormones, amount of secretory tissue, and ability to consume and digest feed. Extreme examples of inherited metabolic differences are the beef cow, which readily converts feed to flesh, and the good dairy cow, which converts it to milk. A more thorough understanding of the inheritance of mechanisms which control production is needed, and much research is being directed to obtaining this information.

Cows which have inherited a capacity for high production are necessary if the benefits of excellent management are to be fully realized. However, many of the cows presently in dairy herds are managed in such a way that their potential production is never realized. The potential production of a given animal cannot be raised by management practices, but good management should take full advantage of the capacity that is present.

Age. The age of a cow has a definite effect on total milk production. Most cows reach maturity and maximum production at six to eight years of age. Production gradually increases to this point, then tends to drop off. An increase in production of approximately 25 per cent is achieved at maturity in comparison to that of most two-year-olds. Breed association and other production-recording agencies take this into account in calculating production records to a *mature equivalent* (ME) basis. Conversion tables have been developed for this by a number of groups, including the Agricultural Research Service of the United States Department of Agriculture and each of the breed associations. Table 2.4 contains factors developed from the Cooperative Dairy Herd Improvement Program for converting production records to the ME basis.

Fat percentage changes but little from the first lactation to maturity, but tends to drop slightly with advancing age after maturity.

Feed effects on milk during lactation. There are a number of ways in which feed may affect the quantity and/or composition of milk. Probably the most striking factor is the level of energy intake.

Underfeeding of cows has a marked depressing effect upon the quantity of milk produced. The degree of reduced production is related to the extent of underfeeding and the length of time it exists. Cows in good flesh may show less decline in milk as a result of underfeeding than thin animals.

One of the most critical periods for proper feeding is immediately following parturition. It is difficult for high-producing cows to consume enough feed to completely supply the energy demands for production and maintenance at this time. Most good cows lose weight at this period. Bringing cows to full feed as rapidly as possible after calving and maintaining energy intake as close as possible to their total need will enable them to reach their inherited potential for production and to maintain it for longer periods.

As cows approach their inherited capacity for milk production, they respond with decreasing amounts of additional milk for each unit of energy added to the ration. This is demonstrated by the graph shown in Figure 2.8.

A ration well balanced in regard to all nutrients is essential for normal milk production. Deficiency of any specific nutrient in relation to the requirements of the cow will reduce the efficiency of the ration and result in decreased milk production. With a few exceptions, the decrease in milk production, rather than significant changes in the composition of milk, is the response to an unbalanced ration. However, markedly decreased milk production as a result of underfeeding may be accompanied by changes in the composition of milk. Fat and protein percentages frequently increase, resulting in increases in percent total solids. The percentage of lactose frequently decreases. These changes

TABLE 2.4. FACTORS FOR CONVERSION OF RECORDS OF MILK AND FAT PRODUCTION TO THE MATURE EQUIVALENT BASIS.*

Factor	Ayrshire (Years and Months)	Brown Swiss (Years and Months)	Guernsey (Years and Months)	*Holstein* (Years and Months)	Jersey (Years and Months)
1.48		1 — 0			
1.47		1 — 10			
1.46		1 — 11			
1.45		2 — 0			
1.44		2 — 1			
1.43		2 — 2			
1.41		2 — 3			
1.39		2 — 4			
1.37		2 — 5		1 — 0	
1.36	1 — 9				
1.35		2 — 0		1 — 10	
1.34	1 — 10				
1.33		2 — 7		1 — 11	
1.32	1 — 11				1 — 9
1.31		2 — 8	1 — 0	2 — 0	
1.30	2 — 0			2 — 1	1 — 10
1.29	2 — 1	2 — 9		2 — 2	
1.28	2 — 2		1 — 10	2 — 3	1 — 11
1.27	2 — 3	2 — 10			2 — 0
1.26	2 — 4		1 — 11	2 — 4	2 — 1
1.25	2 — 5	2 — 11		2 — 5	2 — 2
1.24	2 — 0		2 — 0	2 — 0	2 — 3
1.23	2 — 7	3 — 0	2 — 1	2 — 7	2 — 4
1.22	2 — 8		2 — 2	2 — 8	2 — 5
1.21	2 — 9	3 — 1	2 — 3	2 — 9	2 — 0

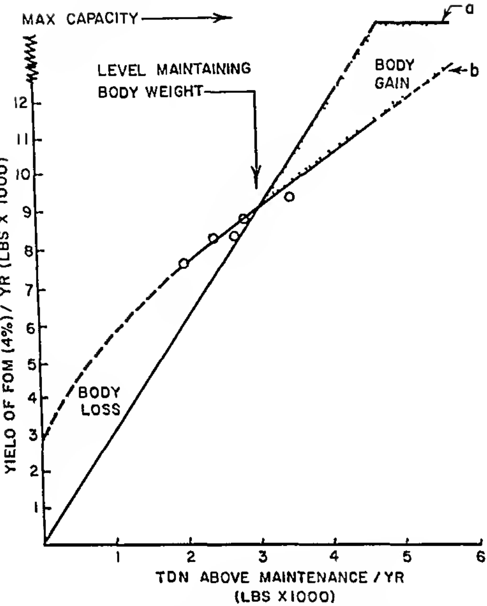
TABLE 2.1.—Continued

Factor	Ayrshire (Years and Months)	Brown Swiss (Years and Months)	Guernsey (Years and Months)	Holstein (Years and Months)	Jersey (Years and Months)
1.20	2 — 10	3 — 2	2 — 4	2 — 10	2 — 7
1.19	2 — 11	3 — 3	2 — 5	2 — 11	2 — 8
1.18	3 — 0	3 — 4	2 — 6	3 — 0	2 — 9
1.17	3 — 1	3 — 5	2 — 7	3 — 1	2 — 10
1.16	3 — 2	3 — 6	2 — 8	3 — 2	2 — 11
1.15	3 — 3	3 — 7	2 — 9	3 — 3	3 — 0
1.14	3 — 4-5	3 — 8	2 — 10	3 — 4	3 — 1
1.13	3 — 6-7	3 — 9	2 — 11	3 — 5	3 — 2
1.12	3 — 8-9	3 — 10	3 — 0	3 — 6-7	3 — 3
1.11	3 — 10-11	3 — 11	3 — 1	3 — 8	3 — 4
1.10	4 — 0-1	4 — 0	3 — 2	3 — 9-10	3 — 5
1.09	4 — 2	4 — 1-2	3 — 3-5	3 — 11	3 — 6-7
1.08	4 — 3-4	4 — 3-4	3 — 6-8	4 — 0	3 — 8-9
1.07	4 — 5	4 — 5-6	3 — 9-11	4 — 1	3 — 10-11
1.06	4 — 6-7	4 — 7-8	4 — 0-2	4 — 2	4 — 0-1
1.05	4 — 8-9	4 — 9-10	4 — 3-5	4 — 3-4	5 — 1
1.04	4 — 10-11	4 — 11-	4 — 6-8	4 — 5-6	5 — 2-6
		5 — 1			
1.03	5 — 0-1	5 — 2-4	4 — 9-11	4 — 7-11	4 — 2-3
1.02	5 — 2-6	5 — 5-7	5 — 0-2	5 — 0-6	4 — 4-5
					4 — 6-9
1.01	5 — 7-11	5 — 8-11	5 — 3-6	5 — 7-11	4 — 10-

* From Kendrick, J. F., "Standardizing and Improving Dairy-Herd Improvement-Association Records in Proving Sires." U.S. Department of Agriculture, ARS-52-1. 1955.

TABLE 2.4 —Continued

Factor	Ayrshire (Years and Months)	Brown Swiss (Years and Months)	Guernsey (Years and Months)	Holstein (Years and Months)	Jersey (Years and Months)
1.00	0 – 0-	0 – 6-	5 – 7-	6 – 0-	5 – 7-
	8 – 6	8 – 0	7 – 5	8 – 5	7 – 5
1.01	8 – 1-11	8 – 1-	7 – 6-	8 – 6 8	7 – 6-
		6 – 5	8 – 0		8 – 6
1.02	6 – 0-11	9 – 6-	8 – 1-	8 – 9-	8 – 1-
		10 – 5	9 – 6	9 – 2	9 – 0
1.03	10 – 0	10 – 0-11	9 – 1-11	9 – 3 8	9 – 1-
	11 – 11				9 – 11
1.04	11 – 0-	11 – 0-5	10 – 0 5	9 – 9-	10 – 0 5
	11 – 5			10 – 2	
1.05	11 – 6-11	11 – 6-11	10 – 6-11	10 – 3 8	10 – 6-11
1.06	12 – 0 5	12 – 0 5	11 – 0-5	10 – 9-	11 – 0 5
				11 – 2	
1.07	12 – 0-	12 – 0 11	11 – 6 11	11 – 3 0	11 – 6-11
	13 – 2				
1.08	13 – 3	13 – 0-5	12 – 6-5	11 – 7-10	12 – 0-5
	13 – 11				
1.09	14 – 0	13 – 6 11	12 – 6-11	11 – 11-	12 – 0-11
				12 – 2	
1.10		14 – 6	13 – 0 5	12 – 3 6	13 – 0-5
1.11			13 – 6-11	12 – 7-10	13 – 0-11
1.12			14 – 0	12 – 11-	14 – 0
				13 – 2	
1.13				13 – 3 6	
1.14				13 – 7-11	
1.15				14 – 0	



[a] Perfect conversion of energy based on present feeding standards
[b] Expected production from experimental data adjusted for maintenance and intake level
From Reid J T Paper Presented before the American Dairy Science Association June 1955

Figure 2 8 Relation of milk yield to energy intake above maintenance

may result in changes in the physical properties of milk, such as the freezing point, which may be interpreted by control authorities as indicative of added water

Specific rations or feed ingredients influence the composition of milk Cod liver oil in the ration has long been known to reduce the fat percentage of milk Other fish oils have a similar effect The feeding of butterfat, coconut oil, and fats of similar structure results in a temporary increase in the fat content of milk There seems to be no evidence of feedstuffs which will result in increases in the percentage of fat secreted over the entire lactation

Certain rations do result in significant depression of the fat content of milk Feeding limited amounts of forage and heated concentrates of a starchy nature results in lowered fat percentage of milk. Grinding the forage accentuates this effect There are indications that the fatty acid content of the butterfat is altered when these rations are fed, with an increase in unsaturated fatty acids There may also be some increase in the protein content of milk secreted under these feeding conditions Cows on certain pastures and cows on high-concentrate feeding may exhibit a depression of fat content of the milk Pearl millet has been associated with this phenomenon Lush spring pastures seem to contribute to a similar change

In general, lack of adequate forage dry matter or adequate sources of energy seem to contribute to situations where the fat content of milk is reduced Feeding cows a minimum of ten or twelve pounds of normal dry forages seems to assure milk of normal composition Changes in fat content and composition of milk appear to be a result of differences in the proportions of volatile fatty acids made available to the mammary gland from the rumen

The amounts of fat soluble vitamins A, D, and E in milk are influenced by the amount in the diet or, in the case of vitamin D, the amount of exposure to sunlight

The relationship of carotene and vitamin A has been previously discussed, when the diet of cows is deficient in fat soluble vitamins and they are not exposed to sunlight, there will be little or none in the milk.

Feed factors affecting the flavor of milk. A number of natural feed stuffs cause undesirable odors and flavors in milk Wild onion and garlic are particularly bad offenders Many silages also contribute odors to milk Fresh spring pasture may be a cause of undesirable flavors Research has shown that many milk flavors are transmitted through volatile substances being inhaled and passed into the blood stream of the cow through the lungs Other flavoring substances are absorbed from the digestive tract From the blood the flavors are incorporated in milk. Upon separation of the cow from the source of contamination many flavors will disappear from the milk. It is essential that cows be kept from exposure to undesirable odors and flavor sources for at least four hours previous to milking

Effect on milk of feeding previous to lactation The feeding level previous to calving determines the condition of flesh of the cow at parturition. Cows in good flesh at calving have been observed to start the lactation with up to 25 per cent more milk than those calving in poor flesh Generous feeding of thin cows following parturition may eliminate this difference soon after calving.

Cows calving in an extremely fat condition may produce milk of unusually high fat percentage during the first several weeks after calving

Length of dry period. A dry period of six to eight weeks in duration is recommended following each lactation period. This is important for proper conditioning of the udder. Under this system there is practically complete involution of the secretory tissue and replacement with new tissue between lactations. An opportunity is also provided to get the cow in proper body condition for calving. While longer dry periods frequently result in higher daily levels of production in the subsequent lactation, the total milk produced over a series of lactations is not increased.

Effect of season. The percentage of butterfat secreted in milk varies with the season, being higher in the fall and winter and lower in spring and summer. This variation in individual cows may be as much as 1.0 per cent. The average variation is closer to 0.3 to 0.5 per cent. Solids-not-fat also show a seasonal variation, with the low point in spring and summer. The reason for these changes is not known. They may be associated with temperature and humidity, or with other factors, including type and amount of feed consumed.

The season of calving has a marked effect on total production of milk and fat during a lactation. Cows calving in the fall months consistently produce more than those calving at other times of the year. Cows calving in the spring produce the least. This difference may be of the order of 10 or 15 per cent. It is due in part, at least, to the ability of cows calving in the fall and early winter to respond to spring feeding conditions with additional production. Cows calving in the fall have an advantage in fat production, since they are at the peak of total milk secretion during the season of high fat test.

Severe weather conditions usually decrease the amount of milk and may influence fat test in either direction. Temperatures above 85° F. are critical for dairy cows. Above this temperature, feed consumption is greatly reduced. High humidity associated with high temperatures may be even more serious. Milk production in hot weather frequently follows the pattern produced by very low intake of feed.

Breed. The various breeds of cattle have been in part selected for specific characteristics of the milk, and there are appreciable differences. Table 2.2 contains data on the average composition of milk from different breeds. It should be remembered that there is a great deal of variation in regard to the composition of milk produced by individual animals within each breed.

Gestation. Pregnancy seems to have little effect on milk production until about the fifth month. At this time production begins to decline more rapidly than with non-pregnant animals. This reduction in production is probably largely due to changing hormone balance rather than to the nutrient requirements of the developing fetus, since these are small in relation to those for milk secretion.

Estrus cycle The reproductive cycle has little effect on production except at the time of heat During the day of heat and the day following total production and butterfat percentage may vary drastically either up or down without any consistent pattern

Frequency of milking and interval between milkings Milking high producing cows three times a day consistently provides greater production than milking twice daily Likewise, four milkings per day result in more milk than three milkings There is wide variation in the response of individual cows As much as one fourth to one third more milk has been reported in some instances for cows milked three times instead of twice daily Milking good producing cows only once daily severely curtails production and persistency of lactation

One of the advantages of milking three or more times per day is greater persistency Not only is more milk obtained on a given day, but production declines at a slower rate as lactation progresses

Frequency of milking has not been shown to have a significant influence on butterfat percentage

Unequal intervals between milkings result in differences in both quantity and composition of milk More milk of slightly lower fat content is obtained following the longer interval When the time between milkings is equal, the morning milk tends to be slightly lower in butter fat content but somewhat greater in quantity

The decision as to whether more than two milkings per day are profitable will depend on whether the additional milk more than covers the cost of obtaining it Some herds managed for intensive production have shown three daily milkings profitable

Frequency of calving The interval between calvings is an important management problem in a dairy herd Research has indicated that it is most profitable for cows to calve at twelve month intervals With an eight week dry period this means a lactation period of ten months More milk can be obtained in a single lactation with longer calving intervals but total production over two or more years is greatest with the yearly calving interval

Drugs A variety of drugs have been tested to determine their effect on milk production There are a number of substances which may have a depressing effect on milk secretion and these are of interest and help in studying the physiology of milk secretion Drugs which stimulate milk production are few One substance sometimes recommended to increase production is *thyroprotein or iodinated casein* which, when given in sufficient quantity speeds up the metabolism of the entire body Milk and fat production may be increased particularly in good producing cows in the last half of lactation The energy requirement is also greatly increased The possible effect on milk production in subsequent lactations is in question The use of thyroprotein is not recom

mended except under specialized conditions. Its use is not allowed with cows on some "official" production-testing programs.

Oxytocin is sometimes used beneficially with cows which are deficient in this hormone. It may be useful in obtaining milk from heifers which are excitable and where difficulty is experienced in training to milk. The effect of this drug is to facilitate removal of milk from the udder rather than stimulation of secretion.

Disease. Any disease which has a harmful effect on a cow tends to reduce milk production. When feed intake is reduced, the effect may be drastic. Diseases of the reproductive system have an indirect but severe effect on production by prolonging the calving interval.

Mastitis has a direct effect on milk composition as well as quantity. The chloride content is increased. Frequently the sugar level is decreased. The characteristics of the proteins are changed and the content of body cells is tremendously increased; as a result, the pH of the milk is increased. Milk from cows suffering from mastitis should not be used for human consumption.

Management of the cow. Management factors other than those just mentioned probably have little effect on the composition of milk. However, much can be done to maintain the level of production. The cow must be considered as a hard-working individual converting tremendous quantities of rough feed into high-quality human food. Creating a pleasant, quiet, and comfortable environment will enable her to do her job more efficiently and effectively.

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3 Feeding Dairy Cattle

THE feeding of dairy cattle and other ruminants is approached quite differently from the feeding of swine, poultry, and other animals which do not have so complicated a digestive system. All animals which live to a large extent on the vegetative parts of plants have a portion of the digestive tract designed for bacterial action on the food. In the horse, as well as in the guinea pig and other rodents, it is a greatly enlarged caecum, which is associated with the intestine. In cattle, sheep, goats, deer, and similar animals, this fermentation area is located in the forward part of the digestive tract and called the *rumen*. Because of the tremendous volumes of rough feed processed in the rumen and converted to high-quality human food, the rumen is frequently spoken of as one of our most important natural assets. An understanding of the structure and functioning of the digestive tract of cattle is necessary for the determination of the rations which will result in the most efficient production.

RUMINANT ANATOMY AND PHYSIOLOGY

The names given to the different sections of the stomach of ruminants, in order of occurrence, are *rumen, reticulum, omasum,* and *abomasum.* The relative location of these organs is shown in Figure 3.1.

The first compartment, or rumen, makes up about 80 per cent of the stomach in the mature ruminant, with the reticulum, omasum, and abomasum accounting for approximately 5, 7, and 8 per cent, respectively. Total capacity of the mature ruminant stomach may be 50 gallons or more. This is a marked change from the case in the newborn calf where the rumen and reticulum together are only about one-half the size of the abomasum. The rumen is a highly muscular organ which is lined with a mucous membrane containing many *papillae*, or small projections, which greatly increase the surface area. Food material moves over a muscular wall to the reticulum, which, in addition to being lined with papillae, has a system of ridges and depressions which resemble a honeycomb. The term "honeycomb" is frequently used as a name for the reticulum.

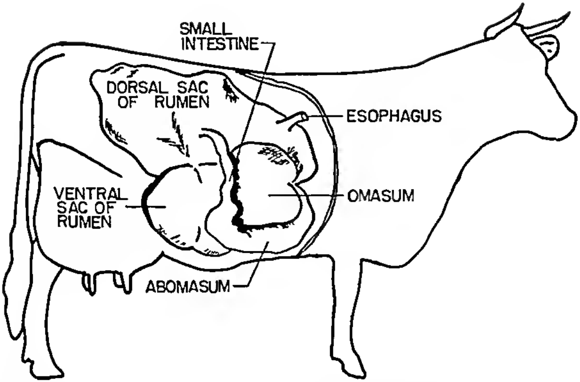

Figure 3.1. Location of the rumen and other parts of the ruminant stomach. The reticulum is located behind the abdomasum and the omosum, just to the reor of the diaphragm

The omasum is shaped somewhat like a cabbage and is filled with "leaves" of flesh with food particles between them. There are about five different heights of these folds, ranging from one-fourth inch or less to some that stretch nearly across the organ. The only part of the wall of the omasum that does not have these folds is the small food passage which runs along the internal side and connects the reticulum and the abomasum.

The abomasum has a structure and function similar to that of the single stomach compartment of swine and man.

An additional interesting structure in the stomach of ruminants is the *esophageal groove.* This is a double muscular fold which runs from the lower opening of the esophagus across the wall of the reticulum to the opening in the omasum. In young calves, the sucking reflex causes the esophageal groove to close, and milk obtained by sucking is moved directly to the last two stomach compartments. Liquids drunk from a pail by calves apparently flow more directly to the rumen and reticulum. The nature of liquids consumed also affects the closing of the esophageal groove. For example, milk tends to cause it to close more effectively than water. In mature animals, the esophageal groove may be closed by giving a dose of copper sulfate. This is sometimes done in giving medicines which need to bypass the rumen to be effective.

Another unique feature of cattle and sheep is that they have no upper

incisor or canine teeth Goats and some other ruminants do have them The usual molars are present in cattle and sheep

Parts of the digestive tract other than those mentioned are similar in ruminants to those found in other species

Function of the Parts of the Digestive Tract

The rumen serves as a large fermentation or digestion vat and as a reservoir for food for cattle Varying amounts of water are always present Feed consumption is a rapid process in ruminants with only enough chewing when food is first eaten to moisten it with saliva so that it can be swallowed Upon arrival in the rumen, food is suspended in the watery contents It is mixed by the rhythmic contractions of muscles in the walls of the organ Lighter, larger particles of food float near the top, while heavier, smaller particles drop to the bottom and move to the lower part of the digestive tract

During several periods of each day, when the animal is at rest, specific rumen contractions, coupled with movements of the chest wall, force a *bolus* (or compact mass) of food into the mouth of the animal, where it is thoroughly chewed This is commonly referred to as "chewing the cud" or ruminating When chewing is completed, the bolus is returned to the rumen for further digestion

There are no known digestive secretions from the rumen All digestive activity in this organ is performed by microorganisms which are present in extremely large numbers, up to 10 billion per milliliter of rumen contents The major digestive functions are thought to be carried on by bacteria, but there are large numbers of protozoa present which perform some functions Research has shown that much of certain digestion products produced by the microflora are absorbed into the blood stream through the walls of the rumen—for example, most volatile fatty acids

The reticulum The reticulum is closely associated with the rumen and is considered to have a similar function Many people refer to the two compartments in the singular as the *reticulo rumen*

The omasum The function of the omasum is not well understood It has been shown that water and some materials in solution are absorbed through its walls The food residues between the leaves of tissue are quite dry and closely packed, giving the organ a high degree of firmness This may be mistaken for an abnormality or impaction by those not familiar with its normal state

The abomasum As previously stated, the abomasum functions much the same in ruminants as the single stomach compartment of other animals

Microflora of the Rumen in Digestion and Synthesis of Nutrients

The rumen microorganisms are entirely responsible for the ability of cattle and other ruminants to make use of hay, silages, and all fibrous feeds. Complex carbohydrate materials such as cellulose are attacked by enzymes from the bacteria and broken down to materials called *volatile fatty acids.* These acids are absorbed through the walls of the rumen and may account for as much as 70 per cent of the food energy available to the cow.

In addition, the rumen microorganisms provide their host with several essential nutrients. Vitamins of the B complex are synthesized by rumen bacteria in quantities which make it unnecessary to include them in the diet. Amino acids necessary for normal function are also provided by these bacteria. Thus, the quality (kind and proportions of amino acids) of protein fed to ruminants is a matter of much less concern than it is for poultry and swine. Under favorable conditions, a significant portion of the needed protein may be formed by the microorganisms from nitrogen in non-protein sources such as urea.

The mutual-assistance activities of the ruminant in providing a home for bacteria, which in turn digest fibrous feeds, produce essential nutrients, and, indeed, are finally themselves digested by the host, is not only an interesting phenomenon but is extremely valuable in our food economy.

NUTRITIVE REQUIREMENTS OF CATTLE

Energy

Energy, which is defined as the ability to do work, is a primary ingredient in all feeding programs. It is essential for growth, movement, and, in the case of dairy cows, the secretion of milk. It is the element most frequently deficient in dairy-cattle rations.

There are several systems for stating the energy requirements of cattle and the energy content of feeds. Only those in common use in this country will be considered.

Total digestible nutrients (TDN) is expressed in pounds per day when referring to animal requirements. It is expressed as per cent or pounds per 100 pounds when referring to the amount present in a given feed. The TDN content of a feed can be determined only in a digestion trial where known amounts are consumed and the nutrient composition of the feed and feces as well as the amount of feces produced from the

feed are known. The formula used to calculate the TDN content of a feed is:

$$\text{Per Cent TDN} = \left(\frac{\text{D.P.} + \text{D.C.F.} + \text{D.N.F.E.} + (\text{D F.} \times 2\ 25)}{100 \text{ lbs. of feed}}\right) \times 100$$

In this formula D.P. = digestible protein, D C.F. = digestible crude fiber, D.N.F.E = digestible nitrogen-free extract, and D.F. = digestible fat.

Protein, an essential nutrient in all animal feeds, is discussed in the next section. Crude fiber and nitrogen-free extract represent two fractions of the carbohydrate material of the feed. Fat represents the food material that is soluble in ether, and is multiplied by 2.25 because there is 2.25 times as much energy in a given weight of fat as in the other nutrients used in the formula. The amount of each of the above nutrients digested is determined by subtracting the amount present in the feces from that in the feed.

An example of some of the calculations involved in determining the TDN value of a feed follows.

Several steers eat 10 pounds of alfalfa hay per day and excrete an average of 25 pounds of feces

	Composition of Hay		Composition of Feces		Amount Digested	TDN
	(%)	(lbs.)	(%)	(lbs)	(lbs)	(lbs)
Water	10	1 0	85 0	21.25	——	——
Protein	15	1.5	2.0	0.50	1 00	1 00
Crude fiber	30	3 0	5.3	1.25	1 75	1 75
Ether extract	2	0.2	0.04	0 10	0 10(2.25)	.22
Ash	7	0 7	2.0	0.50	0.20	0.20
N F E	36	3 6	5 6	1 40	2.20	2.20
		10 0		25 00		5.37

Per cent TDN of this sample of alfalfa $= \left(\frac{5.37}{10}\right) \times 100 = 53\ 7.$

TDN values for concentrates and feeds not suitable for making up an entire ration are determined by feeding them in combination with forage of known TDN content and calculating a value for the concentrate under study by subtraction.

The TDN requirement for a specific function or species is determined by feeding material of known TDN content and measuring the response in terms of maintenance and production.

Digestible energy (DE) is determined in a manner similar to TDN but by a somewhat simpler procedure. The total energy of a feed is measured by burning it in a device, called a *bomb calorimeter*, designed to measure the heat of combustion. The total energy of the feces is determined in the same way The energy which disappeared in the animal

—which was not excreted in the feces—is called *digestible energy.*

Digestible energy is designated by Calories or therms. The basic unit of energy measurement in this system is the *small calorie,* which is the energy required to raise the temperature of one gram of water from 14.5°C to 15.5° C. The large Calorie, characterized by a capital *C,* is the unit commonly used in expressing energy needs in human nutrition. It represents 1,000 small calories. A therm represents 1,000 large Calories or 1,000,000 small calories.

The evaluating of feeds by their digestible energy has seen only limited use in the United States in the past. Because of its more direct determination of Calories and the wider availability of necessary equipment, it will probably be used more in the future.

Metabolizable energy is seldom used in describing the feeding of large animals but is mentioned so frequently that it should be understood. It is based upon the subtraction of energy losses in the feces, urine, and combustible gases (largely methane in ruminants) from the total energy in the feed. More of the energy not available for productive purposes is accounted for in this system than by TDN or DE.

Net energy (NE), while not used as a method of expressing nutritive requirements or feeding value in practical rations in this country, is the basis for a system which is so used at times. This is the most specific method of expressing energy requirements or feeding value. It involves determining energy excretion in the feces, urine, combustible gases, and heat increment—or work of digestion and assimilation—which is measured as heat given off by the animal's body. The determination of NE is expensive and complicated, and only limited information is available with respect to it on feeds. However, since it is the most specific measurement available, more usable information about it is needed. Considerable active research on determining NE values is in progress.

Estimated net energy (ENE) values, developed by Morrison, are frequently used in expressing energy requirements of animals and contribution of feeds. Briefly, the method of determination is to compare carefully the productive value of a feed under study with that of corn or other feed for which reasonably accurate NE values are available. Actual feeding trials must be used for this. The ENE value for the feed in question is calculated in relation to the production from it in comparison with production from the feed of known energy value.

ENE is used in establishing feeding rates in many instances. It is also the method used in evaluating feeding programs for Dairy Herd Improvement records processed by the electronic system developed by the U.S.D.A. This is discussed more thoroughly in Chapter 6.

Each of the systems for evaluating energy may be used satisfactorily in developing rations for cattle, provided both the requirements of the animals and the energy content of feedstuffs are expressed in the same

TABLE 3.1. DAILY NUTRIENT REQUIREMENTS FOR DAIRY COWS
(Based on air dry feed containing 90 per cent dry matter)

Body Wgt (lb)	Daily Gain: Small Breeds (lb)	Daily Gain: Large Breeds (lb)	Daily Nutrients per Animal [a]: Feed (lb)	Total Protein (lb)	Digestible Protein (lb)	TDN (lb)	DE [b] (therm)	Ca (gm)	P (gm)	Carotene (mg)	Vitamin D (IU)
			Maintenance of Mature Cows [c]								
800	—	—	12	0 95	0 50	0 0	11 7	0	0	32	d
1000	—	—	14	1 13	0 60	7 0	14 1	8	8	40	—
1200	—	—	10	1 32	0 70	8 0	10 0	10	10	18	—
1400	—	—	19	1 51	0 80	9 0	19 0	11	11	50	—
1600	—	—	21	1 01	0 87	10 0	21 2	12	12	01	—
			Reproduction (Add to maintenance during last 2 to 3 months)								
—	2 0	2 0	8 0	1 13	0 60	0 0	12 1	8	7	30	d
			Lactation (Add to maintenance for each pound of milk)								
		Milk of—									
—	—	3 0% fat	—	0 062	0 040	0 28	0 57	1	0 7	e	e
—	—	4 0% fat	—	0 070	0 045	0 32	0 05	1	0 7	—	—
—	—	5 0% fat	—	0 078	0 050	0 37	0 75	1	0 7	—	—
—	—	0 0% fat	—	0 086	0 055	0 42	0 85	1	0 7	—	—

units A factor in favor of the ENE system is that it is much more accurate when one is comparing the feeding value of concentrates and forages and attempting to arrive at the most economical ration The difficulty with the TDN and related systems is that they tend to overevaluate forages in comparison to concentrates This is so because there are more losses in combustible gases and in the work of assimilation for forages than for concentrates

In the United States feeding standards which contain tables of nutrient requirements or allowances for dairy cattle and other animals frequently list energy allowances in more than one form Table 3 1 contains information on energy requirements in TDN and DE for dairy cows of different weights Similar information for calves and heifers is presented in Chapter 6

Because of variation in energy content between feeds from different areas and between different lots 10 to 15 per cent more energy should be allowed under most farm conditions than is called for in Table 3 1

Energy allowances for maintenance Amounts of energy required to maintain the weight of mature animals are presented in Table 3 1 People closely associated with the feeding of dairy cattle find it helpful to keep in mind a few representative values as aids in evaluating dairy cattle rations It may be noted from Table 3 1 that 7 pounds of TDN are required daily for maintenance for a cow weighing 1 000 pounds This is increased to 8 pounds of TDN for cows weighing 1,200 pounds Cows weighing 1 500 pounds need about 9 5 pounds of TDN Cows in poor flesh need some feed in addition to the usual allowance for maintenance Cows in the first or second lactation should be fed enough for adequate growth The requirements for growth given in Table 6 1 may be used for these animals or about 4 pounds of TDN per day may be added to the figures in Table 3 1 Grazing cows may require up to 40 per cent additional energy for maintenance on account of their extra activity

Energy allowances for lactation A major portion of the energy needs of high producing cows is for milk production Energy requirements for each pound of milk produced are set forth in Table 3 1 Milk of high fat content requires appreciably more energy About 15 per cent more energy must be supplied for the production of a pound of milk containing 4 5 per cent fat than is needed for a pound of 3 5 per cent milk A good value to remember when calculating rations is 0 32 pounds of TDN for each pound of milk containing 4 0 per cent fat

Adequate supplies of energy are particularly important during the very early part of lactation Frequently, high producing cows are unable to consume enough energy to support their capacity for production During this period energy intake should be increased as rapidly as possible while still maintaining good feed acceptance by the cows

Additional allowance for pregnancy The total energy requirement

for pregnancy is not large, but allowance must be made for this important work of the cow. The usual recommendations are to supply the amounts of energy indicated in Table 3.1 during the last two or three months of pregnancy. Cows in good flesh may need somewhat less than the amounts listed. Cows in poor flesh sbould be given more.

Protein

Protein, or substances from which protein can be synthesized by bacteria in the rumen, is essential for the formation of tissue in growth, for the maintenance of these tissues, and as a source of the proteins in milk. There is no protein requirement for exercise or work. Excess protein is easily metabolized by the body for energy purposes and may be utilized directly or stored as fat. For this reason it may be economically sound to overfeed protein in instances where it is cheaper than other energy sources. Dairy cows can make use of protein equivalent from urea or other nitrogen sources for up to one-third of their protein in a ration well balanced in regard to other nutrients.

Measurement of protein. The protein content of feeds is determined by chemical analysis which measures the nitrogen present. Since nitrogen occurs in a constant percentage of specific proteins, it is possible to calculate the amount of protein in a feed from this value. It is generally assumed that the protein of common feedstuffs contains 16.0 per cent nitrogen. Thus, multiplying the per cent of nitrogen in a feed by 6.25 gives the per cent of protein. Protein values obtained by the above method are referred to as "crude protein," since nitrogen from other than true protein may be included. Protein values shown on feed tags and commonly expressed for forages are for crude protein.

Feeding recommendations for livestock are usually expressed as "digestible protein." The method of determination is mentioned in the discussion of TDN. Most tables of feed composition similar to Table 3.2 include digestible protein as well as crude protein.

Recommended allowances of protein for growth of calves and heifers. The quality as well as the quantity of protein must be considered for young calves, which are in reality non-ruminants. After the age of four to six weeks, or whenever the calf starts ruminating, the quality of protein becomes less important. Milk supplies the best protein for the baby calf, but research workers have developed some satisfactory substitutes, as is pointed out in the section on calf feeding, where a more complete discussion is presented.

Recommended allowances of protein for maintenance. Table 3.1 contains information on the levels of digestible protein required for maintaining mature animals. Digestible protein needs vary more directly with body weight than do energy needs. A cow weighing 1,000 pounds

needs about 0.60 pounds of digestible protein per day. A 1,200-pound cow should have 0.70 pounds and one weighing 1,500 pounds, about 0 85 pounds.

Recommended allowances af protein for lactation. The utilization of feed protein for milk is one of the most efficient biological proeesses known. Approximately 83 per cent of the digestible protein allowed for milk production in a well-balanced ration is secreted in the milk. An average figure to remember is that 0 045 pound of digestible protein is required for eaeh pound of milk containing 4 per cent fat. The requirement is 0 040 pound digestible protein for milk containing 3 per cent fat and 0.050 pound for milk containing 5 per cent fat.

Additional allowance af pratein for pregnancy. Just as additional energy is required to support pregnancy, some extra protein is neeessary. As indicated in Table 3 1, the equivalent of approximately 0.60 pound per day for the last two or three months of pregnancy should be supplied.

Fat

Systems of measuring fats. Fat in concentrates and forages is determined by extraction by ether or other substances which readily dissolve it. In addition to true fat, pigments and other materials are dissolved. In many forages, the pigments, which include carotene, chlorophyll, and xanthophylls, make up the major portion of the extracted material. Because of this, the term *ether extract* is frequently used in place of the word *fat* and is more correct.

Recommended allowances of fat for calves and heifers. There is a definite requirement for fat in the diet af the young calf. In some experiments, a diet with as little as one to two per cent fat bas provided reasonably good results. One need is for a "carrier" for fat-soluble vitamins.

Milk fat is ideally suited for the young calf. Other animal fats and hydrogenated vegetable oils may be used successfully as substitutes. Natural vegetable oils are not recommended as the source of fat in calf rations. The amount of fat in milk is ample for calves. Average milk contains 28-30 per cent fat on a dry-matter basis. The milk of high-testing breeds may contain more fat than is desirable for greatest success in raising calves.

Milk replacers (feeds designed to replace milk during the early weeks of the life of the calf) containing 10 to 12 per cent fat on a dry-matter basis have been quite successful. One-half of this amount or less has proved satisfactory in experimental rations.

Supplying fat in the ration of heifers after the rumen has become functional is not a problem. Normal rations apparently contain adequate amounts.

Recommended allowances of fat for maintenance, lactation, and pregnancy. Fats occurring naturally in usual rations appear to be adequate to provide for maintenance and lactation in ruminants.

Fat for milk production and body needs can be produced within the animal's body from the digestion products of carbohydrates. Unless energy can be purchased cheaper in the form of fats than from other sources, there is little economic advantage in feeding concentrates containing fat in addition to what is normally present.

Minerals

Methods of measurement. The total mineral content of feeds is determined by burning the feed and weighing the ash. This method, while used almost universally, includes some impurities. Quantities of individual minerals are determined by chemical methods which are specific for them. The mineral needs of cattle are determined similarly to those for other nutrients, that is, by feeding adequate rations except for the mineral under study and determining how much must be added for normal function.

Recommended allowances of minerals. Some 15 mineral elements have been shown to be essential in animal nutrition, and these are probably all needed by dairy cattle. Most of these elements occur in adequate amounts in usual feeds and are not of serious concern.

Common salt, phosphorus, and calcium should always be considered in developing rations for dairy cattle. Suggested daily amounts of calcium and phosphorus are included in Table 3.1.

The requirement for salt by growing animals is usually adequately supplied by adding one per cent salt to the concentrate mixture and providing, free-choice, a source of salt after the calf is a few months old. Mature lactating animals need about one ounce of salt each day. This may be supplied by the above methods.

Cobalt has been found to be deficient in the soil in some areas of the United States. Forages grown in these areas lack sufficient cobalt for normal ruminant nutrition. In places where cobalt supplementation is needed, 2 ounces of a cobalt salt per ton of feed is sufficient. Iodine must also be added to the diet in large areas of this country. This is particularly true around the Great Lakes and throughout the northwestern section of the country. This element can be supplied cheaply by feeding iodized salt.

A relative deficiency of magnesium occurs in feeds grown in various parts of the country. Animals maintained on these feeds exhibit a typical "tetany" when exposed to stress. Additional magnesium in the diet is not always effective in preventing this condition. Much more accurate

information on this condition is essential before satisfactory recommendations can be made.

Crops grown on very sandy or badly leached soils may be deficient in a number of minerals. Under these conditions, many of the essential minerals may need to be added to usual feeds. When desired, adequate mineral supplements can be added to the concentrate mixture for a few cents per ton. There is no need to purchase high-priced mineral supplements.

Vitamins

Vitamins are required by all animals to help carry out the reactions necessary for the body's metabolism. Only minute quantities are needed in relation to the amounts of other nutrients.

Systems for measuring vitamins. Many vitamins can be measured by specific chemical and physical techniques, but biological methods are frequently employed. These involve feeding the material in question to bacteria, or in other cases to specified test animals, and measuring the response in terms of total growth, bone formation, or other changes. Requirements for vitamins are established in a manner similar to that for minerals.

Specific vitamins needed. The B-complex vitamins have already been mentioned as being synthesized by bacteria in the mature rumen. Vitamins A and D must be supplied to all ruminants from outside sources. Vitamin C is produced in adequate amounts by the tissues of cattle. When eaten, this vitamin is destroyed in the rumen.

Vitamin E is associated with normal muscle metabolism and may play a part in controlling oxidized flavors in milk.

Vitamin B_{12} is important in preventing certain types of anemia. It may be deficient in animals not receiving sufficient amounts of cobalt. This mineral is an essential part of the B_{12} molecule, and if cobalt is not present, normal amounts of B_{12} will not be synthesized.

Quantitative requirements of cows for carotene are listed in Table 3.1. A dietary requirement for Vitamin E in cattle rations has not been established.

Vitamin A as such is found only in animal tissues or products such as milk. The pigment carotene, occurring in plants, is converted to vitamin A in the animal body. The recommended allowance of carotene for all cattle is approximately 6 milligrams (mg.) per 100 pounds live weight per day. Additional carotene should be provided for the last few months of pregnancy in the amount of 30 mg. per day. The amount of carotene in the ration directly affects the amount of carotene or vitamin A found in the milk.

Vitamin D. Normally, vitamin D is supplied in adequate amounts

by sun-cured forages or by exposure of the animal to sunlight. Chemicals in the skin are converted to vitamin D by action of ultraviolet light. Under usual farm conditions, vitamin D supplies are not a problem. It may be profitable to supply 400 International Units of vitamin D per 100 pounds live weight to young calves if they are not exposed to sunlight. This is undoubtedly a generous allowance.

Water

Water is the cheapest ingredient in dairy cattle rations but of utmost importance. Mature cows consume an average of 12 to 15 gallons of water a day and high-producing ones up to twice this amount. Ready access to water is important. Cows with water constantly available have been shown to produce more milk than those watered twice a day and over 10 per cent more than those watered once a day. A source of clean water is also important for the growth of animals.

NUTRIENT CONTRIBUTIONS OF FEEDS

The nutrient content of a selected list of the more common forages and concentrates is given in Table 3.2. It should be remembered that these are average figures, and indivdual samples of a feed may vary considerably. Knowledge of the nutrient content of feeds is essential if selections of adequate rations to fit the needs of dairy cattle are to be made.

Forages, sometimes referred to as *roughages,* in general comprise the vegetative part of plants fed to livestock. Common materials are hay, hay-crop silage, corn silage, and pasture crops. These feeds are characterized by being bulky, high in fiber, and low in energy as compared with concentrates.

Concentrates are so called because of their relatively higher energy content in relation to forages. The common grains contain from 70 to 80 per cent TDN. Seeds or by-products high in fat contain more energy, with a few going above 100 per cent TDN because of a lot of fat. By-products of the processing of grains for human consumption are also considered concentrates, and many are very profitably included in rations for cattle. Protein-rich grains and by-products are also included in concentrate feeds.

Borderline feeds which are difficult to characterize in either of the above groups include oat hulls and other low-grade products which are derived from grains or other materials during processing. Some of these materials are frequently sold as concentrates but have n feeding value closer to forages.

TABLE 3 2. AVERAGE COMPOSITION AND DIGESTIBLE NUTRIENTS

Feedstuff	Total Dry Matter (%)	Protein (%)	Dig Protein (%)	TDN [a] (%)	DE [b] (therms/lb)	Calcium (%)	Phosphorus (%)	Carotene (mg/lb)
			Dry roughages					
Alfalfa hay, all analyses	90.5	15.3	10.9	50.7	1.02	1.47	0.21	8.2
Alfalfa hay, 1/10 to 1/2 bloom	90.5	15.1	11.2	51.4	1.04	1.47	0.21	20.3
Alfalfa hay, 3/4 to full bloom	90.5	14.1	10.2	50.3	1.02	1.22	0.22	8.5
Alfalfa hay, past bloom	90.5	12.9	9.3	47.7	0.90	1.10	0.20	3.3
Alfalfa meal, dehydrated	92.7	17.7	12.4	51.1	1.10	1.00	0.20	12.4
Alfalfa leaf meal, dehydrated	92.7	21.1	10.0	57.2	1.10	1.69	0.25	02.0
Barley straw	90.0	3.7	0.7	42.2	0.85	0.33	0.10	—
Birdsfoot trefoil hay	91.2	14.2	9.8	55.0	1.11	1.60	0.20	19.7
Bromegrass hay, all analyses	88.8	10.4	5.3	49.3	1.00	0.42	0.19	—
Clover hay, alsike, all analyses	88.0	12.1	8.1	53.2	1.07	1.15	0.23	—
Clover hay, crimson	89.5	14.2	9.8	48.0	0.99	1.23	0.21	—
Clover hay, Ladino	89.5	18.5	14.2	59.5	1.20	1.53	0.20	—
Clover hay, red, all analyses	88.3	12.0	7.2	51.8	1.05	1.28	0.20	7.3
Clover and mixed grass hay, high in clover	89.0	9.0	5.5	51.8	1.05	0.88	0.21	0.1
Clover and timothy hay, 30 to 50% clover	88.1	8.0	4.7	51.0	1.03	0.69	0.10	—
Corn cobs, ground	90.4	2.3	0.0	45.7	0.92	0.11	0.04	—
Corn stover, medium, in water	89.3	5.8	2.0	45.5	0.92	0.48	0.08	—
Lespedeza hay, annual, before bloom	89.1	14.3	7.2	49.2	0.99	1.03	0.20	20.4
Lespedeza hay, annual, in bloom	89.1	13.0	9.1	46.1	0.91	1.00	0.10	—
Lespedeza hay, annual, after bloom	89.1	11.5	3.0	39.0	0.80	0.90	0.15	—
Mixed hay, good, less than 30% legumes	89.2	8.8	4.8	48.8	0.99	0.60	0.10	0.4
Oat hay	88.1	8.2	4.0	47.3	0.90	0.21	0.10	—
Oat straw	89.8	4.1	0.7	44.8	0.90	0.24	0.09	—
Orchard grass hay, good	88.7	8.1	4.2	49.7	1.00	0.27	0.18	—
Prairie hay, western, cut in mid season	91.3	6.0	2.0	45.1	0.91	0.33	0.12	9.1

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TABLE 3.2.—Continued

Feedstuff	Total Dry Matter (%)	Protein (%)	Dig. Protein (%)	TDN [a] (%)	DE [b] (therms/lb.)	Calcium (%)	Phosphorus (%)	Carotene (mg./lb.)
Prairie hay, western, mature	91.9	4.4	0.9	43.7	0.88	0.30	0.08	3.0
Reed canary grass hay	01.1	7.7	4.9	45.1	0.91	0.33	0.10	—
Sorghum fodder, sweet, dry	88.9	0.2	3.3	52.4	1.06	0.34	0.14	1.1
Soybean hay, good, all analyses	88.1	14.0	9.8	48.0	0.98	1.10	0.22	13.0
Timothy hay, all analyses	89.0	0.0	3.0	49.1	0.99	0.35	0.14	4.4
Timothy hay, before bloom	89.0	9.7	0.1	56.0	1.14	—	—	9.2
Timothy hay, full bloom	89.0	0.4	3.2	51.1	1.03	—	0.20	4.2
Timothy hay, late seed	89 0	5 3	1.9	41.9	0.85	0.14	0.15	2.5
Timothy and clover hay, ⅓ clover	88.8	7.9	4 0	49 8	1.01	0.58	0.15	—
Wheat straw	92 0	3.9	0 3	40.0	0.82	0.15	0.07	—
	Silages, roots, and tubers							
Alfalfa, not wilted, no preservative	24.7	4.1	2.0	13 5	0 27	0.35	0.08	15.1
Alfalfa, wilted	30.2	0.3	4.3	21.5	0.43	0.51	0.12	11.4
Clover, Ladino, and timothy	29.9	5.4	3.9	21.4	0.43	0.31	0.07	15.6
Corn, canning factory waste	22.4	2.0	1.1	10.1	0.33	—	—	—
Corn, dent, well matured, all analyses	27.0	2.3	1.2	18.3	0.37	0.10	0.07	5.8
Corn, dent, well matured, well eared	28.5	2.3	1.3	19 8	0.40	0 09	0.07	—
Corn, dent, well matured, fair in ears	20.3	2.1	1.1	17.2	0.35	0.09	0.00	—
Corn, dent, immature, before dough stage	20.3	1.8	0.9	12.9	0.20	0.11	0.07	—
Corn stover, mature ears removed	23.7	1.0	0.0	14.0	0.28	0.08	0.10	—
Corn and soybeans, well matured, 30% or more soybeans	28 3	3 2	2.0	19.7	0.40	0.20	0.08	—
Grass silage, considerable legumes	25 0	3.6	2.0	15.5	0.31	—	—	17.1

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TABLE 3 —Continued

Feedstuff	Total Dry Matter (%)	Protein (%)	Dig Protein (%)	TDN[a] (%)	DE[b] (therms/lb)	Calcium (%)	Phosphorus (%)	Carotene (mg/lb)
Grass silage, some legumes	27.0	3.2	1.9	15.0	0.32	—	—	20.7
Pea vine	21.5	3.2	1.9	11.0	0.30	0.32	0.06	21.0
Sorghum, sweet	25.4	1.0	0.8	15.2	0.31	0.08	0.05	2.7
Soybean not wilted	21.8	4.2	2.9	14.0	0.29	0.35	0.09	14.6
Sudan grass	25.7	2.2	1.5	11.1	0.29	0.11	0.04	—
Timothy, not wilted no preservative	30.9	3.3	1.8	18.1	0.37	0.18	0.09	14.1
Timothy, not wilted, molasses added	30.0	3.1	1.0	17.1	0.35	0.10	0.08	—
Concentrates								
Barley, excluding Pacific Coast	89.1	12.7	10.0	77.7	1.57	0.06	0.40	—
Barley, Pacific Coast	89.9	8.7	0.9	78.8	1.59	0.06	0.33	—
Beet, pulp dried	90.8	0.1	4.3	68.2	1.38	0.68	0.10	—
Bone meal steamed	05.2	12.1	—	—	—	28.08	13.59	—
Brewers dried grains	92.4	25.9	20.7	66.0	1.33	0.27	0.50	—
Citrus pulp, dried	90.1	0.0	5.2	78.2	1.58	1.96	0.12	—
Coconut meal, expeller	92.8	20.1	17.3	70.3	1.54	0.21	0.61	—
Coconut meal, solvent	01.7	21.3	18.1	68.3	1.38	0.17	0.01	—
Corn and cob meal	80.1	7.1	5.1	73.2	1.48	0.04	0.22	—
Corn, yellow dent, #2	85.0	8.7	0.7	80.1	1.02	0.02	0.27	1.3
Corn, flint	88.5	9.8	7.5	83.1	1.68	—	0.33	—
Corn, distillers dried grains	02.3	27.1	19.8	82.7	1.67	0.09	0.37	1.1
Corn, distillers dried grains, with solubles	91.9	27.2	19.9	81.0	1.01	0.17	0.68	1.7
Corn distillers dried solubles	93.1	20.9	21.3	80.2	1.02	0.35	1.37	0.3
Corn gluten feed	90.1	25.3	21.8	75.4	1.52	0.10	0.77	3.8
Corn gluten meal	00.7	42.0	30.5	70.9	1.01	0.10	0.40	7.4
Hominy feed white	89.8	11.1	7.9	82.9	1.67	0.02	0.58	—
Hominy feed, yellow	90.7	11.1	7.9	83.7	1.69	0.05	0.52	3.1

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TABLE 3.2.—Continued

Feedstuff	Total Dry Matter (%)	Protein (%)	Dig. Protein (%)	TDN [a] (%)	DE [b] (therms/lb.)	Calcium (%)	Phosphorus (%)	Carotene (mg./lb.)
Linseed feed	90.5	33 8	28.4	74 2	1.50	0.43	0.65	—
Linseed meal, expeller	90.9	35.3	30.7	76.3	1.54	0.44	0.89	—
Linseed meal, solvent	90.9	35.1	29.5	71 0	1.43	0.40	0.83	—
Milk, cow's	12 8	3.5	3.3	16.3	0.33	0.12	0.10	—
Molasses, beet	76.0	6.7	3.5	59 6	1.20	0.16	0.03	—
Molasses, cane	74 5	3.2	2.0	54.9	1.11	0.89	0.08	—
Oats, excluding Pacific Coast	90.2	12.0	9.4	70.1	1 42	0.09	0.33	—
Oats, Pacific Coast	91.2	9.0	7.0	72.2	1.46	—	—	—
Peanut meal, expeller	92.0	45 8	41.7	80.2	1.62	0.17	0.57	—
Peanut meal, solvent	91.5	47.4	43 1	74.3	1.50	0.20	0 65	—
Potato meal, dried	90.3	5.9	2.1	65.1	1.32	—	—	—
Rice bran	90 6	13.5	9.2	71.0	1.43	0.06	1.82	—
Rye, distiller's dried grains	93 0	22.4	13.4	60.2	1.22	0.13	0.41	—
Skim milk, dried	93.9	33.5	30.2	80.3	1.62	1.26	1.03	—
Sorghum, Kafir	89.8	11 0	8 9	81.6	1 85	0.03	0.31	—
Sorghum, milo	89 0	10.9	8.5	79.4	1 60	0.03	0.28	—
Soybeans	90 0	37.9	33.7	87.8	1.77	0.25	0.59	—
Soybean meal, expeller	89.7	43.8	38 8	77 0	1.56	0.27	0.63	—
Soybean meal, solvent	89.3	45 8	42.1	77.2	1.56	0.32	0.67	—
Wheat, hard, winter	89.4	13.5	11.3	79.8	1.61	0.05	0.42	—
Wheat, hard, spring	90.1	15.8	13.3	80.7	1.63	0.04	0.40	—
Wheat, soft, winter	89 2	10.2	8.6	80.1	1.62	—	0.29	—
Wheat, soft, Pacific Coast	89.1	9 9	8.3	79.9	1.61	—	—	—
Wheat bran	89.1	16.0	13.0	65.9	1.33	0.14	1.17	1.2
Wheat flour middlings	89 8	18.4	18.2	78.2	1.58	0.11	0.76	—
Wheat standard middlings	89.7	17.2	14.3	78.9	1.55	0.15	0.91	1.4

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Energy Content of Feeds

The section on nutrient requirements includes a discussion of several systems of expressing requirements and listing the energy content of feeds The TDN and DE systems are included in Table 3.2.

The numerical values expressed for the energy values of feeds are quite different for these two systems. It must be remembered that TDN is expressed in per cent or pounds per 100 pounds of feed, while DE is expressed in therms per pound of feed. It is well to remember that the energy content of grains is between 70 and 80 pounds of TDN per 100 pounds. Grain by-products which contain the germ or are low in fiber tend to be higher in TDN.

When used for forages, the ENE system frequently provides a closer approximation of true feeding values This is because ENE accounts for the higher losses in rumen fermentation and metabolism which occur with forages.

The range of energy values for dry forages is wide, as may be seen in Table 3.2. Species plays a part here, but the *most important* factor is date of harvest Early-cut forage has a much higher feeding value than mature forage from the same field The energy values for silages and pasture are low because of the large amount of water in these feeds.

Hays, silages, and pasture plants of a given variety harvested at the same time will have a similar nutrient value on a dry-matter basis if they are not unduly damaged in harvesting or storage.

FOOTNOTES TO TABLE 3.2

[a] In calculating the values for total digestible nutrients, no digestion coefficients were available for a few of the feedstuffs

[b] DE (digestible energy) may be converted to metabolizable energy by multiplying by 82 per cent

The committee on Animal Nutrition is indebted to Professor F. B Morrison for the use of data from the 22nd *Edition of Feeds and Feeding* on the composition of roughages, silages and cereals presented in this table The data on the composition of by-product feeds were supplied by the Committee on Feed Composition of the National Research Council (NRC Pub No 449, 1956) The digestion coefficients used in calculating the digestible protein and TDN were also taken, with Professor Morrison's permission, from the 22nd Edition of *Feeds and Feeding* These are based in part on the extensive compilation of digestion coefficients in *Feeds of the World* (W Va. Agr Expt. Sta., 1947), which was prepared by Dr B H. Schneider at the request of the Committee on Animal Nutrition.

Taken from National Research Council Publication 464, *Nutritive Requirements of Dairy Cattle* Revised 1958 With Permission of The Morrison Publishing Company, Clinton, Iowa.

Protein Content of Feeds

See Table 3.2 for average values in regard to the protein content of feeds. As mentioned earlier, the protein needs of animals are expressed as digestible protein, while total protein is often the only value available for a given lot of feed. An approximation of the digestible protein in a specific lot of feed may be obtained by comparing it with the value for average feeds of the same type and total protein content in Table 3.2. Allowance should be made for the type and age of animal for which such approximations are made. For example, protein from vegetable sources is not well utilized by young calves when included in milk replacers.

Forages vary a great deal in protein content. Legumes, which include alfalfa, all clovers, lespedeza, soybean, and peanut hays, are relatively high in this nutrient. Grasses usually contain less than half as much protein as legumes. However, if grasses are fertilized with high levels of nitrogen, they may approximate legumes in protein content. The protein content of plants harvested for hay decreases with maturity and becomes very low at the seed stage. The digestibility of the protein in forages also decreases with the maturity of the plant, so that very late-cut hay may have an extremely low content of digestible protein.

Concentrates exhibit greater variability in protein content than do forages. Several concentrate feeds, particularly those made from seeds from which the oil has been extracted, are high in protein (soybean meal, cottonseed meal, linseed meal). These are commonly used to bring up the protein content of a mixed feed or a total ration to supplement the protein contained in forages. In general, grain by-products are richer in protein than the common small grains. Because of the ability of the rumen to synthesize required amino acids, any single source of natural protein or one containing up to 30 per cent of the total ration from urea or other synthetic protein is adequate for cattle.

Fat Content of Feeds

The fat content of feeds is not a problem in ruminant feeding, and this nutrient is of minor concern. In forages much of the ether extract is composed of pigments such as chlorophyll and carotene rather than true fat. Present methods of processing remove all but a small portion of fat from the oil-seed meals.

In some instances, feeds high in fat or waste fats from plant processing may provide economical sources of energy. Animal fats are recommended at only low levels in rations for mature ruminants because of poor acceptability.

Mineral Content of Feeds

Minerals of major concern in ruminant feeding are calcium, phosphorus, and common salt. Other minerals required by ruminants are usually found in sufficient amounts in typical rations. However, there are specific area deficiencies in parts of the world where plants do not contain sufficient amounts of trace minerals and supplementation is necessary. Salt is inadequate in nearly all feeds and they must be supplemented with it. High-quality forages tend to be the best sources of calcium, while most of the natural phosphorus in ruminant rations is supplied by concentrates.

Forages are quite low in phosphorus, as indicated in Table 3.2. Plants grown on soils low in phosphorus or harvested at advanced stages of maturity are lacking in this element. In contrast, legume forages are relatively rich sources of calcium. Grasses are appreciably lower in calcium, containing one-third to one-half as much as legumes. Calcium, while reduced in mature forages, is not affected as severely as phosphorus.

Concentrates vary somewhat in their contributions of calcium and phosphorus. Cereal grains contain a fair amount of phosphorus but are poor contributors of calcium. Several of the by-product feeds, particularly wheat bran and middlings, are important sources of phosphorus. The oil-seed meals are also good sources of phosphorus but are low in calcium.

Vitamin Content of Feeds

Vitamin A, as supplied by its precursor carotene, is the vitamin of most concern in rations for mature ruminants. The carotene content of several feeds is shown in Table 3.2. All forages which exhibit some green color contain carotene, and if some color is still present in hay or silage, it will usually supply adequate amounts of carotene. However, degree of green color does not always indicate the relative amount of carotene present. Yellow corn also serves as a source of carotene.

Vitamin D is found in adequate amounts in plant products only after exposure to sunlight after normal life processes have stopped. Sun-cured hay, while varying a great deal, contains appreciable amounts of vitamin D.

Feed Additives

A great many substances other than naturally occurring plants and their by-products are frequently offered for use in rations of dairy

cattle. A number of these are listed below with comments as to their nutritive worth.

Urea or other simple sources of nitrogen. Useful when fed as recommended in the section on practical rations.

Vitamin A or D preparations. Useful when a deficiency is present and in rations for young calves.

Hormones. Not shown to benefit dairy cattle, except possibly thyroid-active materials under very specific conditions.

Yeasts. Not shown to benefit dairy cattle, except irradiated yeast as a source of vitamin D.

Complex mineral mixtures. Of value only in geographic areas where deficiencies occur.

Enzyme preparations. Present research information shows no benefit for dairy cattle.

Rumen bacteria preparations. No benefit demonstrated by present research results.

Feed flavoring agents. Present research information indicates little or no effect on intake by dairy cattle.

DEVELOPING PRACTICAL AND ECONOMICAL RATIONS

The task of developing practical and economical rations may be defined as one of evaluating all the nutrient needs of the animal in question and filling them from feeds which are palatable, provide necessary physical characteristics, and are the least expensive available. Considerable variation in rations for dairy cows is possible owing to the versatility of the rumen microorganisms in synthesizing nutrients needed by the host animal.

Rates and Types of Forage Feeding

Forage forms the basis of all ruminant rations, and minimum amounts are essential for normal function of the digestive tract of dairy cattle. In some areas, energy from forages is cheaper than that from concentrates. Here it is common practice to allow free access to them and to supply supplemental nutrients from concentrates. Under this system, forage consumption will vary widely. If poor-quality material is provided, as little as one pound per 100 pounds of body weight per day may be eaten. When high-quality, early-cut forages are available, consumption may reach three and one-half to four pounds per 100 pounds of body weight per day. Interestingly, recent research observations indicate that free-choice consumption of forages is closely related to nutrient content. This means that more energy is available from each pound of forages eaten at high rates than from those less readily eaten.

The most reliable method of obtaining estimates on rate of consumption of a given forage is a feeding trial. Reasonable estimates may be made by experienced cattle feeders with a good understanding of forage quality. Accurate records of the amount of forage actually consumed are essential.

Date of harvest appears to be a critical factor in forage quality, particularly for the first harvest in the spring. Research data indicate a decline in dry-matter digestiblity of approximately 0.5 per cent per day for forages during the period of first growth.

In some instances there appears to be an advantage in feeding producing cows a few pounds of top-quality forage each day.

When forages are in short supply or expensive, it may be profitable to reduce their intake and feed additional concentrates. However, reducing forage consumption below 10 to 12 pounds of hay-equivalent per head per day may result in the cow going off feed, with a drop in production and also decreased fat percentage in the milk.

All forages fed to lactating cows, whether home-grown or purchased, must be free of pesticides which may occur as residues in the milk.

Silage versus hay for dairy cows. Corn silage is well liked by cattle and may be fed in large amounts. Some dairymen successfully supply nearly all the forage in this form. Hay-crop silage, when of good quality, is well liked by cattle and may also be fed heavily. Some research has indicated that better forage consumption and production are obtained when considerable hay is offered along with grass silage. Even with highly palatable corn silage, five or six pounds of additional forage dry matter will usually be eaten each day if some dry hay is offered.

In comparing the feeding value of silage and hay, one pound of hay is usually considered equivalent to three or three and one-half pounds of silage. This is to allow for the difference in moisture content.

Pasture for dairy cattle. Fresh green pasture forage is highly palatable to dairy cattle and is an economical source of nutrients. Production is well supported by good pastures. However, rapidly growing pasture may be so high in water content that it supplies inadequate nutrients even though the cows are full. Frequently, as hot weather approaches, pastures stop growing and supply only limited feed. Under both of these conditions, supplementary feeding is important to maintain production. The activity of cows on pasture increases the energy required for maintenance in proportion to the amount of work involved. As much as 40 per cent increase in maintenance requirement may occur.

Green chop or soiling for dairy cows. The practice of chopping green feed and hauling to dairy cows has created considerable interest. This provides a satisfactory source of forage if the fresh material is handled so that it does not heat or ferment. The economical use of this

practice depends upon whether the additional 20 or 30 per cent of nutrients harvested from a pasture crop pays for the labor, equipment, and management factors involved.

Rates of Feeding and Types of Concentrates

The function of the concentrate portion of a dairy ration is to supplement nutrients supplied by forages. Energy, protein, and minerals are the nutrients usually considered.

Determining energy needs. The need for supplemental energy usually determines the amount of concentrate to be fed. The amount of energy needed in the concentrate may be expressed in several ways. Ratios of concentrates to total milk produced are unreliable and overfeed low producers while not providing enough for high producers. Calculations based upon maintenance requirement, amount, and fat test of milk, as shown in the section on sample rations, may be used. Perhaps a sounder way of determining concentrate needs is to feed at the rate of one pound of concentrates to each two to two and one-half pounds of milk produced, in addition to that supported by nutrients from forage.

Underfeeding of energy to dairy cows is probably the most frequent nutrient deficiency observed in this field. The response of the individual cow is extremely important in arriving at the most economical level of concentrates to supply. Table 3.1 shows the average requirement for energy to produce milk. The actual utilization of energy for this purpose is probably more accurately expressed by Figure 2.8, page 37. It may be seen here that, at higher feeding rates, as the level of intake increases, there is a diminishing rate of return in milk production.

The most profitable level of concentrate feeding for a given cow is at the rate where the last increment of concentrate is just more than paid for by the milk produced as a result of its inclusion in the ration. Controlling feeding to this degree requires intensive management and close attention to the program.

Determining protein needs. Protein levels to be fed are calculated in a manner similar to energy levels. Knowledge of the amount of concentrate to be fed and the amount of protein needed makes it possible to calculate the percentage of protein needed in the grain mixture. Sample calculations are shown below. Concentrate mixtures are usually made up to contain 12, 14, 16, or more per cent of crude protein. In calculating the protein content of rations, the significance of digestible and of total protein should be kept in mind.

A good point to remember is that an entire ration of forage and concentrate containing 11 to 12 per cent total protein will usually be adequate for dairy cows. Under practical feeding conditions, it is seldom

necessary to employ a concentrate ration above 16 per cent in protein, except when corn silage or other highly palatable forage low in protein is fed. Most forages low in protein (except corn silage) will be poorly consumed, and if enough energy is supplied in the form of a concentrate mixture containing 16 per cent protein, this nutrient will also be adequate.

Mixtures containing 12 per cent protein, or less, are recommended for cows fed: (1) early-cut legumes (hay or silage) with or without corn silage, or (2) legume pasture or an excellent growing grass pasture. As soon as grass pasture begins to mature, change to a higher protein mixture.

Mixtures containing 14 per cent protein are recommended for cows fed: (1) part legume and part non-legume hay or silage, or (2) on a mixed grass-legume pasture where the grasses are in bloom.

Mixtures containing 16 per cent protein are recommended for cows fed: (1) non-legume hay or silage, or (2) grass pastures past the bloom stage.

Mixtures containing 18 to 20 per cent protein are recommended for cows fed: (1) corn silage as the principal forage, or (2) highly palatable but low-protein non-legume hay or other forage.

In many instances where legume forages are used, the protein needs will be exceeded by the forage alone. In these cases any concentrate source to provide energy is satisfactory if it is palatable. There is no danger to the animal in overfeeding protein.

Urea and similar sources of nitrogen may be used to supply a portion of the total protein requirements of ruminants. Care should be taken that urea is uniformly mixed in the feed. It should supply not over 30 per cent of the total protein equivalent consumed. Urea should not be included in amounts exceeding three per cent by weight of a mixture, to be fed dairy cattle, or five per cent in a protein concentrate designed to be mixed with other grains.

The specific ingredients to be used in a concentrate mixture can vary widely. Cost should be one of the major deciding factors. Frequently mixtures utilizing large amounts of grain grown in the local area are most economical.

Determining mineral needs. The usual recommendation for supplemental minerals in a concentrate mixture is one per cent common salt and one per cent steamed bone meal or dicalcium phosphate. Salt and a source of calcium and phosphate may also be supplied free-choice In areas where specific deficiencies exist, trace minerals may be added. If economical sources are used, all the trace minerals needed by cattle can be supplied for a few cents per ton of concentrate mixture.

CALCULATING RATIONS

As previously stated, calculating practical rations for cattle consists of establishing the nutritive requirements and adjusting the amounts of available feeds to supply them. The following examples show a simple method of doing this. Table 3.3 contains a tabulation of the relative amounts of nutrients which should be present in the rations of mature dairy animals.

TABLE 3.3. NUTRIENT CONTENT OF RATIONS FOR DAIRY CATTLE[a]

(Based on air-dry feed containing 90 per cent dry matter.)

Per Cent of Ration or Amount per Pound of Feed

Body Weight	Total Daily Feed (lb.)	Feed % of Wgt. (%)	Digestible Protein (%)	TDN (%)	DE[b] (therms/lb.)	Ca (%)	P (%)	Carotene (mg./lb.)
			Maintenance of Mature Cows					
800	12	1.8	3.8	50	1.01	0.12	0.12	2.3
1000	14	1.8	3.7	50	1.01	0.12	0.12	2.5
1200	18	1.5	3.9	50	1.01	0.12	0.12	2.7
1400	19	1.4	3.8	50	1.01	0.12	0.12	2.7
1600	21	1.3	3.8	50	1 01	0.12	0.12	2.8
			Lactating Cows					
			8.5	60	1.21	0.30	0.25	1.2
			Maintenance of Breeding Bulls					
1200	18	1.5	5 6	58	1.17	0.12	0.12	2.7
1600	22	1.4	5.5	58	1.17	0.13	0.13	2.9
2000	27	1.3	5.4	58	1.17	0.13	0.13	3 0
2400	31	1.3	5.2	58	1.17	0 14	0.14	3.1

[a] Taken from National Research Council. Nutrient Requirements of Dairy Cattle. Publication 464. Revised 1958.
[b] DE (digestible energy) may be converted to metabolizable energy by multiplying by 82 per cent.

Example 1

Assume that you need a feeding program for a herd of cows averaging 1,200 pounds in weight and producing an average of 45 pounds of milk per day. Forage available consists of average alfalfa hay and good-quality corn silage. Enough is on hand to feed 15 pounds of hay and 40 pounds of silage per head per day. Requirements for TDN, DP, minerals, and carotene are taken from Table 3.1. TDN for maintenance

		TDN (lb.)	DP (lb.)	Ca (gm [a])	P (gm [a])	Carotene (mg.)
REQUIRED		*22 4*	*2.7*	*55*	*42*	*48*
DESIRED [b]		*25.0*	*3 0*			
FEED						
Kind	Amount (lb.)			(lb.)	(lb)	
Alfalfa hay	15	7 6	1.6	0.22	0 03	123
Corn silage	40	7.3	0.5	0 04	0 03	232
Supplied from forage		14 9	2.1	0.26	0 06	355
Concentrate mixture @ 72% TDN and 6.5% DP	14	10.1	0.9	0 04	0 04	
		25 0	3 0	0.30	0 10	

[a] One pound = 454 grams so 45 grams = 1/10 pound.

[b] Feeding 10 to 15 per cent above minimum requirements for energy and digestible protein will be profitable in most cases.

is 8.0 pounds per day: for milk production, 14.4 pounds per day; total, 22.4 pounds per day. Requirements for other nutrients are calculated in a similar manner. Nutrient contributions of each feed are from Table 3.2.

The amount of concentrate needed may be calculated by dividing the amount of TDN desired, but not supplied by forage, by the TDN content of the concentrate, as in the example: $\frac{10.0}{72} \times 100 = 14$ pounds of concentrate needed.

The percentage of digestible protein needed in the concentrate may be calculated by dividing pounds of digestible protein desired, but not supplied by forage, by the pounds of concentrate to be fed. From the example: $\left(\frac{.9}{14}\right) \times 100 = 6.5\%$ digestible protein needed in the concentrate mixture.

A wide variety of ingredients may be used to provide suitable concentrate mixtures. Figure 3.2 is a work sheet which may be used to develop mixtures utilizing locally available feeds.

Calculating a concentrate mixture to fit the requirements in the above example might be done as follows:

	Amount	TDN	Protein Total	Protein DP	Ca	P
Ground shelled corn	860	688	75	57	0.02	0.23
Ground barley	500	388	63	50	0.03	0.20
Wheat bran	400	264	64	52	.56	4.68
Cane molasses	200	109	6	4	1.78	0 16
Iodized (mineralized) salt	20	—	—	—	—	—
Dicalcium phosphate or streamed bone meal	20	—	—	—	5.80	2.72
	2000	1449	208	163	8 19	7.99
		72.4%	10.4%	8 1%	0.4%	0 4%

TABLE 3 4 A WORK SHEET DESIGNED TO AID IN DEVELOPING ECONOMICAL AND EFFECTIVE CONCENTRATE MIXTURES FOR DAIRY CATTLE.

Group	Ingredient	% Protein	TDN %	Suggested Lower Level	Good Level	Suggested Upper Level	Cost per Cwt	Cost per lb TDN	Pounds Used per Ton	Actual Pounds Protein	TDN lbs
I	Corn and cob meal	7	72	0	800	1400					
	Ground shelled corn	9	80	0	800	1400					
	Hominy feed	10	84	0	800	1200					
	Ground or crushed oats	12	72	0	800	1400					
	Ground or crushed barley	12	80	0	800	1400					
	Ground Wheat	13	80	0	400	800					
	From group I			600	1200	1800					
II	Citrus pulp dried	0	71	0	400	800					
	Beet pulp, dried	9	72	0	400	800					
	Molasses	0	64	0	200	200					
	From Group II			0	600	1000					
III	Wheat red dog	18	86	0	400	600					
	Wheat standard middlings	17	77	0	400	600					
	Wheat Bran	10	67	0	400	800					
	From group III			0	400	800					
IV	Brewers dried grains	27	67	0	400	800					
	Coconut oil meal	21	77	0	400	800					
	Corn gluten feed	25	71	0	400	800					
	Distillers dried corn grains	20	84	0	400	800					
	From group IV			0	600	1000					
V	Corn gluten meal	43	80	Use as much of the cheapest high protein feed as is needed to meet the desired protein level							
	Cottonseed meal	44	73								
	Linseed meal	35	77								
	Peanut oil meal	44	77								
	Soybean oil meal	44	79								
	Ground Soybeans	34	87								
	From group V										
					Total per ton of concentrate mixture					A	B

A A 12% concentrate mixture contains 240 lbs. actual protein
A 14% concentrate mixture contains 280 lbs actual protein
A 16% concentrate mixture contains 320 lbs actual protein
An 18% concentrate mixture contains 360 lbs actual protein

B To contain adequate energy, a concentrate mixture should contain at least 1400 lbs TDN per ton

TABLE 3 5 EXAMPLES OF ADEQUATE RATIONS FOR LACTATION [a]

	Digestible protein (lb)	TDN (lb)	DE [b] (therms/lb)	Calcium (gm)	Phosphorus (gm)	Carotene (mg)
Mature lactating cows						
1100 pound cow giving 50 lb 4% milk						
Nutrient requirements	3 05	25 0	51 5	01	10	56
Ration in pounds						
A Alfalfa, 35, barley, 12	1 87	26 9	54 3	279	91	400
B Timothy hay, 11 corn silage, 42, corn and cob meal, 12 soybean meal 5, limestone, 0 2	3 30	27 0	51 5	65	59	310
C Alfalfa hay 20 0, corn silage, 50 0	3 30	26 8	51 1	150 8	10 2	558
1100 pound cow giving 35 lb 5% milk						
Nutrient requirements	2 35	20 0	40 5	13	32	10
Rations in pounds						
A Alfalfa hay, 5, citrus pulp 12 hominy feed, 10 cottonseed meal 2	2 15	21 3	43 0	101	40	57
B Clover timothy mixed hay, 10 corn silage 30 barley, 4 oats, 5, wheat bran, 5	2 37	20 1	11 2	51	19	212
C Alfalfa brome hay, 25 0 (at least 50% alfalfa), corn, 11 0	2 69	21 2	12 8	05 9	13	—
D Alfalfa, 15 0, corn silage, 30 0 corn, 10 0	2 18	21 0	12 1	100 8	12 2	121
F Clover timothy, 25 0 (30 to 50% clover), corn, 10 0, soybean meal, 1 0	2 21	21 5	13 4	79 0	37 0	—

[a] Taken from National Research Council, *Nutrient Requirements of Dairy Cattle* Publication 101 Revised 1058

[b] DE (digestible energy) may be converted to metabolizable energy by multiplying by 82 (82 per cent)

It should be noted that the calcium and carotene requirements are covered by the forage; thus, additional amounts are not necessary in the concentrate. However, additional phosphorus from the concentrate is needed.

The protein content is adequate from the natural grains. If this were not the case, a high-protein feed such as soybean meal should be included.

Table 3.5 includes several rations whicb will provide adequate nutrition for dairy animals.

Determining the Most Economical Ingredients

In many instances it may be necessary to purchase some or all of the ingredients used in a concentrate mixture. Table 3.6 contains information on the relative value of several feed ingredients based upon their energy content. Ground shelled corn is used as the basis of comparison. To find the value of a particular feed in relation to corn, look at Table 3.6 and find the column headed by the figure that is nearest to the current price of corn. Then read straight down to the line for the feed in question. If the price shown in the table for the feed in question is higher than the market price for that feed, it is a better buy than corn. If the price in the table is lower than the market price, corn is the better buy. By checking several feeds in this manner, the most economical ones on an energy basis can be found. Current market prices can be interpolated between those given in *Table 3.6.*

Determining Whether Forages or Concentrates Are A Better Buy

There are a number of situations where a dairyman must decide whether to use forages or concentrates to complete a ration. After the minimum needs for forage have been filled, the decision as to which to use may be based on the cost of energy from the two sources. Table 3.7 contains information which is helpful in making this decision. To find the value of a particular forage in comparison with an average grain mixture (72 per cent TDN), locate the column in Table 3.7 closest to your cost of an average grain mixture. Read down to the line representing the forage. If the value in the table is higher than the market value of the forage in question, it is a better buy than the concentrate mixture. If the value in the table is lower than the market value of the forage, the concentrate mixture is the better buy. Interpolation between the prices shown may be necessary to adjust to the market prices found at any given time.

TABLE 3.6. THE RELATIVE VALUE OF VARIOUS CONCENTRATES FOR DAIRY CATTLE BASED UPON ENERGY CONTENT.

	Feedstuff	PRICE PER 100 LBS						
	Ground Shelled Corn	$2.00	$2.25	$2.50	$2.75	$3.00	$3.25	$3.50
Low Protein Feeds	Ground Barley Ground Wheat Ground Shelled Corn	2.00	2.25	2.50	2.75	3.00	3.25	3.50
	Corn & Cob Meal Ground Oats Molasses	1.80	2.03	2.25	2.48	2.70	2.93	3.15
	Beet Pulp Citrus Pulp	1.90	2.13	2.37	2.60	2.84	3.08	3.31
	Corn Feed Meal	2.04	2.30	2.55	2.80	3.06	3.32	3.57
	Hominy Feed	2.10	2.36	2.63	2.89	3.15	3.41	3.68
Medium Protein Feeds	Wheat Bran	1.68	1.89	2.10	2.31	2.52	2.73	2.94
	Brewers Dried Grains							
	Corn Gluten Feed	1.78	2.00	2.23	2.45	2.67	2.89	3.12
	Wheat Middlings	1.92	2.16	2.40	2.64	2.88	3.12	3.36
	Wheat Red Dog	2.14	2.41	2.68	2.94	3.21	3.48	3.75
High Protein Feeds	Cottonseed Meal Linseed Oil Meal	1.92	2.16	2.40	2.64	2.88	3.12	3.36
	Soybean Oil Meal Corn Gluten Meal	1.99	2.24	2.49	2.73	2.98	3.23	3.48
	Ground Soybeans	2.18	2.45	2.73	3.00	3.27	3.54	3.82

TABLE 3.7. VALUE OF VARIOUS FORAGES

		Price per Ton				
	Average Grain Mix	$40.00	$50.00	$60.00	$70.00	$80.00
Hays	Alfalfa hay, very leafy Clover Hay, excellent	29.20	36.50	43.80	51.10	58.40
	Alfalfa hay, No. 2 Mixed hay, excellent Timothy hay, early	27.20	34.00	40.80	47.60	54.40
	Mixed hay, average Alfalfa hay, stemmy Clover hay, stemmy Soybean hay, good	23.60	29.50	35.40	41.30	47.20
	Timothy hay, late Soybean hay, poor	16.40	20.50	24.60	28.70	32.80
Silages	Alfalfa, wilted Grass silage, wilted (with or without legumes)	12.00	15.00	18.00	21.00	24.00
	Corn, dent, well eared	10.40	13.00	15.60	18.20	20.80
	Sorghum	9.20	11.50	13.80	16.10	18.40
	Corn, dent, few ears Grass silage, not wilted Legume silage, not wilted	8.00	10.00	12.00	14.00	16.00

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4 Reproduction in Dairy Cattle

REGULAR reproduction in a dairy herd is essential for efficient milk production and is one of the most important contributions to a successful operation. If the herd manager is to achieve and maintain satisfactory reproductive efficiency, he must have an understanding of the basic anatomy and physiology involved. The abnormalities and diseases affecting reproduction must also be familiar to him.

Perfect fertility implies that the female is producing normal healthy eggs in numbers common to the species, that each of the eggs is capable of being fertilized by a normal sperm cell, and that the environment in the reproductive tract is such that all the fertilized eggs develop into vigorous, healthy new animals. It also implies that the male produces sufficient numbers of normal healthy sperm to make fertilization of the egg possible at each mating or insemination. Mating must take place at the proper time to bring the sperm and egg together when both are vigorous and active.

The production of offspring at the ideal rate is difficult to achieve. Indeed, at present it requires nearly two breedings for each pregnancy in dairy cattle.

REPRODUCTIVE PHYSIOLOGY OF THE FEMALE

Anatomy of the Reproductive Tract

The major components of the female reproductive tract are the ovaries, fallopian tubes, uterus, consisting of the body and two horns, the cervix, vagina, and vulva The arrangement of these organs is presented in diagrammatic form in Figure 4.1.

The Ovaries are the basic reproductive organs in the female, serving as the source of the egg and of essential hormones. They are located in the abdominal cavity on either side of the midline of the back in the area of the hip bones In the mature cow they are approximately ¾ inch in diameter. At birth the ovary contains hundreds of potential egg cells, which mature individually and are shed during each reproductive cycle.

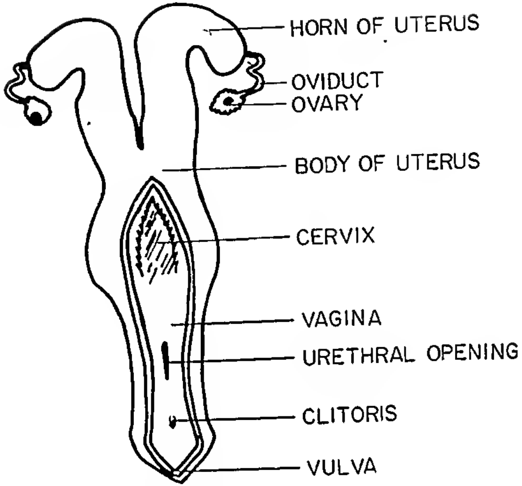

Figure 4.1. Diagram of the parts of the female reproductive tract of cattle.

Each egg develops in a fluid filled sac on the ovary called a *follicle*. In addition to the developing egg the follicle produces a hormone, *estrogen*, which will be discussed further in regard to its importance in reproduction. The ripened follicle bursts and releases an egg approximately 12 hours after the end of each heat period.

At the site of the ruptured follicle a structure develops which is called the *corpus luteum* or *yellow body*. It is responsible for progesterone, another hormone important in reproduction.

The fallopian tubes, or oviducts, provide the connecting link between the ovary and the horns of the uterus. They are convoluted tubules with a fan-like end (infundibulum) which partially surrounds the ovary. Under normal conditions, when the egg is released from the follicle it drops into the infundibulum and is moved by cilia through the tube to the uterus. Fertilization, the union of the sperm and the egg, normally takes place in the upper part of the fallopian tube, with the sperm moving through the uterus to meet the descending egg.

The uterus is a muscular organ consisting of a body and two horns. It is located on the midline of the animal at the rear of the abdominal cavity. During pregnancy in cattle it extends well forward in the abdomen on the right side. The lining of the uterus is heavily supplied with blood vessels and in cattle is characterized by a large number of *caruncles* or button-like elevations. Membranes from the developing embryo become fastened to these caruncles, and nourishment for the fetus passes from the blood of the dam to the blood of the fetus at these points.

The cervix is the term given to the thick walled muscular projection surrounding the mouth of the uterus. It is characterized by a strong sphincter muscle which keeps the opening closed at all times except during parturition. During pregnancy a thick mucous plug seals the cervix.

The vagina is the tubular canal connecting the uterus to the external opening or *vulva*. The urethral canal opens into the vagina for the excretion of urine. The rudimentary equivalent to the penis (the clitoris) projects into the posterior floor of the vagina.

The Estrus Cycle

The reproductive life of cattle, like other animals is characterized by a series of cycles. These cycles begin at puberty or sexual maturity. The estrus (or sexual) cycle in cattle is completed approximately every 21 days. As with all biological activities, there may be considerable variation with individuals. Pregnancy, of course, interrupts the cycle.

In the sexually mature non-pregnant female there is a period of preparation for mating and ovulation (release of the egg). During this period blood supply to the lining of the uterus is increased. The follicle and egg are maturing. The secretion of estrogen from the follicle into the blood stream causes the cow to accept the service of the male. At this time the animal is "in heat." Figure 4.2 illustrates the activities symptomatic of the heat period. "Standing heat" normally lasts for 12 to 18 hours. Since the egg is released approximately 12 hours after the end of standing heat, and since sperm have a limited life in the female reproductive tract, breeding should take place during the last half of the heat period. Following ovulation the corpus luteum (yellow body) forms at the site of the broken follicle. The hormone progesterone, found in this structure, helps prepare the uterus for maintaining the growing embryo. The corpus luteum is essential for the maintenance of pregnancy at least until the latter part of the period.

If fertilization of the egg does not occur, the corpus luteum begins to recede after a short period. The uterus returns to a resting state and the cycle is repeated.

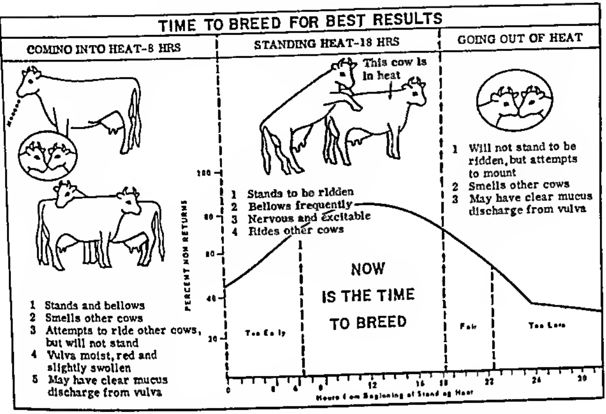

Figure 4 2. Chart showing the symptoms of heat during the three stages of the heat period The graph shows the conception rate at intervals during heat

If fertilization occurs, cell division starts immediately to develop the new animal and the membranes which surround it. The fertilized egg is moved into the horn of the uterus where development takes place. During its early life the embryo obtains its nourishment from a milky fluid secreted by the lining of the uterus. By about 35 to 40 days after fertilization the placental membranes have developed sufficiently to transport nutrients from the blood stream of the dam to that of the embryo. The embryo continues to grow until, at the end of approximately 283 days, the fully developed calf is born.

The operation of a normal sexual cycle is an extremely complex activity which is not completely understood. In addition to hormones from the ovaries those from the pituitary gland, adrenals, and the placenta are involved. The interaction of these hormones is probably as important as the absolute amounts present.

Follicle Stimulating Hormone (FSH) from the pituitary gland is believed to cause the follicle to develop. Estrogen, from the follicle, when it is at a relatively high level in the blood stream, decreases the production of FSH by the pituitary. The pituitary now releases a substance which causes the follicle to rupture.

Luteinizing Hormone (LH), also from the pituitary, is responsible for the maintenance and function of the corpus luteum. Hormones from the placenta play a part here, since if pregnancy does not take place, the corpus luteum soon degenerates.

REPRODUCTIVE PHYSIOLOGY OF THE MALE

Anatomy of the Reproductive Tract

The gross anatomy of the male reproductive tract consists of the testes, epididymis, vas deferens, seminal vesicles, prostrate gland bulbo urethral or Cowpers glands, urethra, and penis Figure 4 3 is a diagram showing the relative location of these organs

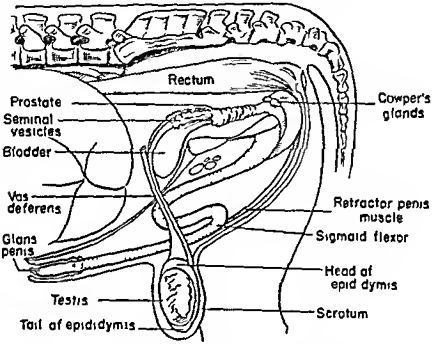

Figure 4 3 Diagram of the parts of the male reproductive tract of cattle

The testes are the primary reproductive organs in the male and perform the dual function of producing sperm and acting as the source of the male hormone, testosterone Testosterone is responsible for the secondary sexual characteristics such as the crest in the bull. Accessory sex glands and the penis fail to develop normally in the absence of testosterone.

Each testicle is normally located in an individual compartment of the scrotum which is outside the body cavity Sperm production does not take place at internal body temperature and the scrotum acts to provide the optimum temperature for this function

Sperm cells originate from the multiplication and maturing of cells lining small canals found in the testes known as *seminiferous tubules* They move through these tubules into the *epididymis* which consists of a single much coiled tubule Here the sperm cells apparently con

tinue to develop and mature to the stage where they are capable of fertilizing ova. The epididymis apparently acts as a storage area for mature sperm. Figure 4.4 is a photograph of sperm from a bull as seen under a microscope.

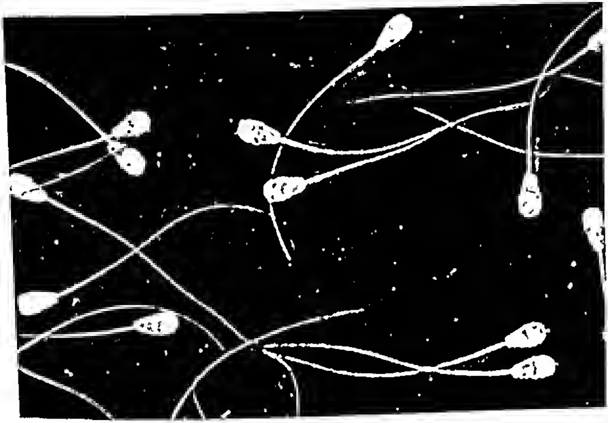

Figure 4.4. Sperm from a bull as it appears under a microscope (India ink background). Courtesy Dr. R H Foote, Cornell University.

The vas deferens serves as a connecting duct between the epididymis and the urethra for the transport of sperm and seminal fluid. It also contains glands which contribute to the fluid portion of the semen.

The seminal vesicles lie alongside the reproductive tract and provide a secretion which enters the urethra along with the material from the vas deferens.

The prostrate gland surrounds the urethra and also provides a secretion which contributes to the fluid portion of the semen. This secretion apparently acts on the fluid to increase the activity of the sperm.

The bulbo-urethral, or Cowpers glands are found on either side of the urethra. The function of the secretion which they provide is not well understood.

The urethra is a duct running from the bladder through the penis of the male and performs the dual function of eliminating urine and transporting the semen to the reproductive tract of the female.

The penis is the copulatory organ of the male which carries the urethra, through which the semen is deposited in the reproductive tract

of the female. The penis is a muscular organ containing areas of spongy tissue which become filled with blood in preparation for copulation. Little increase in the size of the copulatory organ occurs, but the quick thrust, typical of cattle, at copulation is facilitated by relaxation of the retractor penis muscle and the straightening out of the *sigmoid* (S-shaped) *flexure.*

Semen Production

As indicated previously, semen is composed of sperm cells and supporting fluids from a number of glands. In the bull a normal ejaculate amounts to about 5 or 6 cc. This will contain from 2 to 14 billion sperm cells. Research has indicated that 10,000,000 sperm cells are sufficient to assure fertilization under normal conditions. The use of artificial insemination, which is discussed in Chapter 5, is based upon the tremendous numbers of cells produced at one time. The total capability of the male for semen production is not well understood. Bulls in good condition are apparently able to produce enough semen for mating or collecting two or more times per week over extended periods of time.

ABNORMALITIES OF REPRODUCTION CAUSING DECREASED FERTILITY OR STERILITY

Anything which causes dysfunction of the reproductive system results in decreased fertility, or, when reproduction is impossible, complete sterility. Decreased fertility or sterility is not a disease or condition in itself but a symptom of some specific situation which must be corrected before normal fertility can be regained. All degrees of fertility are found in nature, from complete inability to reproduce to complete fertility.

Abnormalities affecting reproduction may be classified in three groups: (1) structural defects, (2) physiological defects, and (3) infectious diseases. Each of these will be considered briefly.

Structural Defects

In the female there are a number of structural defects of a congenital nature which prevent reproduction. However, these occur rarely. Incomplete vaginas, improperly formed uteri, closed cervices and other malformations are among possible defects. Some of these are inherited, and the frequency of occurrence may be increased by inbreeding. Frequently, animals carrying these defects appear normal and have regular heat periods. A condition called *infantile ovaries,* in which the ovaries

fail to develop and produce eggs, sometimes occurs. Normal heat periods do not take place. This is sometimes associated with general underdevelopment as a result of poor feeding. In some cases treatment with hormones is effective.

Heifers born twin to a bull are sterile in about 90 per cent of the cases. This type of animal is known as a *freemartin*. The reproductive tract is incomplete and never develops. No treatment is effective. In suspicious cases, a heifer calf may be checked by gently pushing the rounding end of a test tube or the eraser end of a pencil into the vagina. If penetration is stopped in a short distance in comparison with the penetration possible with a normal calf, the animal is a freemartin.

In the male the most common structural defect is *cryptorchidism* (undescended testes). In this condition the testicles remain in the abdominal cavity and do not descend to the scrotum. Bulls exhibiting cryptorchidism of both testes show normal male characteristics but are sterile. Sterility is attributed to the inability to produce living sperm at internal body temperatures. Bulls with one undescended testicle are fertile but should be screened carefully in a breeding program, since the condition is inherited and sterile male offspring frequently result.

Bulls may have incomplete formation of parts of the reproductive tract similar to abnormalities mentioned for heifers. These are usually incomplete ducts or malformations of the penis.

Hermaphroditism or mixing of the sexes in a single individual is a cause of sterility. However, it is a rarity in cattle, occurring much less frequently than in goats or swine.

Physical injuries resulting from wounds, infections occurring in either sex, or tearing of the uterus during parturition may cause sterility in cattle.

Physiological Abnormalities

In the female, dysfunction of the ovary is a cause of lowered fertility. Some cows exhibit a condition of *nymphomania* (constant or frequent heat). This condition results from "cystic ovaries" or failure of the follicle to break and release the egg at the normal time. The cause is unknown. Some researchers feel that an irritation of the uterus may cause an action upon the ovary which keeps the follicle intact. Secretions from the follicle in turn keep the uterus in a high state of activity and a vicious cycle is set up.

Treatment by a veterinarian in the form of injection of chorionic gonadotrophin, which causes disappearance of the cyst, or manual rupturing can be used. Neither treatment is completely effective, but something like 50 per cent of treated animals conceive when bred at

the first heat after treatment. It is important to treat this disorder as soon as possible after it is discovered.

Persistence of the yellow body on the ovary in the non-pregnant animal results in the absence of heat. Some irritation of the uterus is present when this condition exists, which apparently has hormonal results similar to pregnancy.

The persistent yellow body may be removed by hormonal treatment or manual expression However, this should be done only after careful examination of the cow to determine that she is not pregnant. Also, careful observation should be made to determine that the cow has not passed through a *silent heat* Silent heat is a situation where ovulation occurs but is not preceded by the usual symptoms indicated in Figure 4.2. Current belief is that silent heats are responsible for an appreciable percentage of infertility. Closer than usual observation of the cow is necessary. A bloody discharge on the tail or vulva indicates the cow passed a heat period about 2 days previously, and she should be watched carefully in about 18 days.

In the male, physiological dysfunctions are less frequently observed. While they probably exist, little is known about them. Poor quality sperm or low fertility of certain bulls are undoubtedly a result of physiological malfunctioning in some cases.

DISEASES AFFECTING REPRODUCTION

A number of infectious organisms may invade the reproductive tract and result in decreased fertility through disease These diseases, which include brucellosis, vibriosis, trichomoniasis, and leptospirosis, are covered in detail in Chapter 9. Some information on each is presented here.

Brucellosis is characterized by abortion in the last third of pregnancy. It may be prevented by vaccinating calves between 4 and 9 months of age. The disease is transmissible to humans, and federal and state eradication programs have made excellent progress in eliminating it. If unexplainable abortions occur late in gestation, examination or testing for brucellosis should be conducted. Vaccination of young calves and slaughter of older infected animals are the recommended control procedures.

Vibriosis also causes abortions, frequently so early in gestation that they go unnoticed. It is a true venereal disease, spread by mating. Delayed heat periods, caused by the abortions, and many services per conception are symptoms Bulls may become infected and pass on the disease for many years.

The use of proper antibiotics in the semen diluter used in artificial insemination provides good control of vibriosis.

Trichomoniasis infection frequently results in abortion. As with vibriosis, it occurs early in pregnancy, usually during the first 16 weeks. The organism infects the uterus and the sheath of the bull. It is spread by mating. The disease is sometimes difficult to diagnose because of the problem of identifying the organism when it is present in small numbers. It can be controlled in cows but only with great difficulty in bulls.

Leptospirosis is a disease which has a number of effects and symptoms, one of which is abortion occurring usually in later stages of pregnancy. The disease is spread by several means, but apparently is not transmitted through the semen when artificial insemination is used.

Leptospirosis can be controlled by vaccination which is effective for several months. Vaccination is recommended for cattle being introduced into a herd, or coming in contact with animals from other areas.

Non-specific infections of the reproductive tract from a number of organisms may interfere with reproduction. These may cause abortion or prevent implantation of the embryo in the uterus. Dead tissue in the uterus from failure of a cow to clean properly provides an excellent breeding ground for bacteria. The presence of a colored or pus-like discharge from the reproductive tract is an indication of infection and should always be investigated by a veterinarian and treated if necessary. Infections of the vagina, called vaginitis, are also considered responsible for infertility in some cases.

NUTRITION AND REPRODUCTION

Reproductive failure is frequently blamed on poor nutrition. Serious deficiency of specific vitamins and minerals, such as phosphorus or Vitamin A, has been shown to result in lowered fertility. However, in most carefully observed cases other deficiency symptoms are apparent by the time reproductive efficiency is affected.

Cattle on normal well-balanced rations which include the usually recommended nutrients receive adequate nutrition for reproduction. Correcting inadequate or unbalanced rations with common feedstuffs and supplements is cheaper and equally as effective as using tonics or expensive mineral mixtures.

Research has shown that the plane of nutrition, particularly the energy level, influences the speed at which cattle reach sexual maturity. Six or more months difference in age at first heat has been observed in heifers fed approximately 130 per cent of recommended allowances compared to those fed approximately 60 per cent of the recommended standard. Heifers fed at approximately 90 per cent of the standard showed first heat at about 49 weeks.

INHERITANCE OF FERTILITY

The question is often raised in regard to the possibility of improving breeding efficiency by selection Present information indicates that little is to be gained in selecting animals for general fertility There are a number of specific abnormalities, several of which have been previously mentioned, which are inherited and should be selected against

Abnormal development of the young animal, so that it dies before or shortly after birth, is a cause of inefficient reproduction Several specific abnormalities are well known Many of these are inherited as simple recessive factors Bulldog calves, hairlessness, short spine fused nostrils, dwarfism, and hydrocephaly are among "lethals" which are well recognized Because of the recessive nature of these factors, inbreeding tends to concentrate them

It has been observed that a number of fertilized eggs are lost at a very early stage of development, and that this cannot be accounted for by known diseases This may be a result of abnormalities of such a nature that the embryo cannot develop While it is recognized that a significant portion of infertility is due to early embryonic death, the specific causes and contributing factors are not known

MANAGING DAIRY CATTLE FOR HIGH FERTILITY

Incorporating a knowledge of reproductive physiology and factors affecting it into a good management program should be the goal of every dairyman The following suggested practices should provide a basis for such a program

Proper management for reproduction starts with the growing calf Animals of either sex which are to be used for breeding purposes should be kept constantly in a healthy, vigorous condition

Optimum Age for Beginning Reproduction

The level of feeding has a great influence upon when cattle reach sexual maturity, as described in the section on nutrition and fertility Recommendations for breeding heifers the first time are frequently given in terms of age, however, weight is probably even more important Heifers which have been underfed should not be bred until they have reached proper size The long time effect of breeding very well fed heifers at an early age has not been thoroughly studied If heifers can be brought into production earlier with no shortening of productive life this would have a marked economic advantage Recommended ages and weights for breeding heifers are included in Table 4 1

TABLE 4.1. RECOMMENDED WEIGHTS AND AGES FOR FIRST BREEDING AND CALVING OF DAIRY HEIFERS

	Breed at		Calve at	
Breed	Weight (lbs.)	Age (months)	Weight (lbs)	Age (months)
Brown Swiss and Holsteins	750	15	1100	24
Ayrshires	600	13	850	22
Guernseys	550	13	800	22
Jerseys	500	13	725	22

Heifers of the larger breeds show the first heat at 550 to 600 pounds, Jersey and Guernsey heifers at a somewhat lighter weight.

Detecting heat in cattle requires careful observation and some experience. The symptoms shown in Figure 4.2 should be watched for in all non-pregnant animals. Accurate records should be kept of any animals in heat so that their reproductive cycle can be checked and breeding be done at the desirable time.

The occurrence of a bloody discharge on the vulva or tail of a cow indicates that she was in heat about two days previously and should be watched carefully in about 18 days. Research results have shown that *silent heat* periods occur with a number of cows. That is, they go through the period of ovulation but exhibit little or none of the activity normally expected. Particularly careful observation and accurate records are important in these cases, because cows usually conceive when bred at the proper time. The period during the reproductive cycle when the highest conception rate can be expected is shown in Figure 4.2.

Animals which have been bred and have not returned to heat for 40 to 60 days should be checked for pregnancy by palpating the uterus through the rectal wall. This check should be conducted, on a routine basis, by a veterinarian. An enlarged uterus usually indicates pregnancy.

Diagnosis is difficult prior to 30 days. Checking at this time usually reveals those animals which are not pregnant but have not returned to heat because of some abnormality or which have passed through silent heats. Several chemical and biological tests have been devised to determine pregnancy. At present none are practical.

A regular program of preventative medicine in conjunction with pregnancy checks should be worked out with a veterinarian. Reproduction disorders, like others, respond best to treatment when it is started early.

Animals that have calved should be bred at the first heat occurring 60 days after parturition. Approximately two months are required for the reproductive tract to return to normal after calving. Time is needed

for the removal of inflammation and congestion as well as return of proper muscular tone. Fertilization may take place prior to 60 days *post partum*, but an abnormally large number of the embryos are lost through failure of proper implantation in these early fertilizations. Thus, longer rather than shorter calving intervals frequently result from breeding cows too soon after parturition

The pregnant heifer and cow should be fed according to recommendations in the chapter on feeding. Care should be taken to prevent injuries from fighting, narrow doors, falls or other situations which may result in abortion.

The period of gestation in cattle is approximately 9 months. However, there is considerable variation between breeds and between individuals in a bred. Brown Swiss cattle carry their calves the longest, about 290 days, Guernseys carry calves about 283 days, Ayrshires, Jerseys and Holsteins about 279 days. Male calves are usually carried about a day longer than females. Calves born within 10 days of these periods may be considered normal. Calves born after 7 months of pregnancy frequently live but need special care during early life.

Adequate care at calving time is important in assuring continued fertility of a cow. Symptoms that an animal is about to calve include swelling of the udder (which may start several days, or even several weeks, early in heifers), swelling of the vulva, and a dropping away of the ligaments around the tail head. As calving approaches the cow becomes uneasy and straining is obvious.

Clean, sanitary, and quiet surroundings are ideal for the cow at parturition. An adequate box stall is appropriate. Calving on pasture is satisfactory and often desirable.

Birth usually takes place in one or two hours. Normally the forelegs are presented first with the head resting on top and between them. If the calf is not delivered in a reasonable time and the presentation is normal, assistance may be given by pulling on the forelegs in conjunction with the muscular contractions of the cow.

Abnormal presentations or continued labor with no evidence of birth require the attention of a veterinarian. Immediately following birth, the mouth and nostrils should be checked to determine that they are free of mucus so that normal breathing can occur. A normal, healthy calf will be on its feet and eating within 30 minutes after birth. Care and management of the calf are discussed in Chapter 6.

Normally, the placental membranes, or afterbirth, will be expelled a few hours following birth If they are not expelled in 12 to 15 hours they should be removed by a trained person It is important to carefully separate the membranes from the caruncles in the uterus. Pulling or jerking them free can permanently damage the caruncles so that future

pregnancies are jeopardized. Cattle left to themselves will frequently eat the placenta, so it may not be found.

The reproductive tract should be observed closely following calving. If bloody or pus-containing discharges persist, the cow should be examined to diagnose the cause, and treatment should be carried out promptly.

Following calving, heat periods should be observed and recorded so that the next pregnancy may be started at the desirable time.

Feeding at calving time. The cow or heifer should be brought to calving in good flesh so that she is well prepared for the ensuing lactation. At the time of calving the cow should be provided with plenty of good quality forage and adequate grain. No advantage has been demonstrated for providing special feeds at calving time. Grain feeding should be maintained and increased as rapidly as the cow will accept it after the calf is born. Calving, followed immediately by the onset of heavy lactation, develops considerable stress in a cow. Providing adequate nutrition is important in helping the cow meet this stress.

Research conducted at several stations has demonstrated that the kind or amount of grain fed does not affect the udder edema or congestion frequently observed at calving time.

Milking at calving. The calf should be allowed to nurse as soon after birth as it is able. It is a frequent and satisfactory management practice to leave the calf with the cow for the first two or three days after birth. Then the udder should be milked out, and complete milking at the usual intervals should begin. The colostrum should, of course, not be put in the regular milk supply until normal characteristics appear, usually at the sixth and subsequent milkings.

Pre-milking, or milking previous to calving, is sometimes practiced, particularly in cases where there is a serious problem with udder congestion. No real benefit is apparently achieved by this practice. When this is done, the colostrum is not available at the time the calf is born and special provisions should be made to supply it. Colostrum may be stored frozen or obtained from other fresh cows in the herd.

Udder edema is discussed in detail under diseases, but is of sufficient importance to be mentioned here. It is an accumulation of fluid in the tissues surrounding the udder. In severe cases it may extend completely along the abdomen. It occurs most frequently at calving, but some cows exhibit symptoms throughout much of the lactation. The cause is unknown. Tendency toward udder edema is apparently inherited to some extent. Severe cases may result in breakdown of udder supports, making machine milking difficult and leaving the udder susceptible to injury. No really effective treatment is available. Massage and the use of hot and cold compresses on the udder are frequently suggested.

MANAGEMENT OF REPRODUCTION IN THE MALE

Healthy, well grown bull calves are one of the best assurances of animals which will be good reproducers. The first consideration in selecting bulls is ability to pass on desirable characteristics, as discussed in Chapter 8. Once a desirable bull is chosen, he should be managed for a long lifetime of producing reasonable numbers of normal sperm.

Effect of feed on reproductive performance. Bulls should be fed adequately to keep them in good flesh but not overly fat. Figure 4.5 shows a mature bull in good service condition. Since the nutritive requirements of reproduction are less than for lactation, forage quality and other factors are not as critical for bulls. They should, however, be supplied a well balanced ration. Since the usual feedstuffs can be combined into adequate rations, the use of tonics and expensive mineral mixtures is not recommended.

Figure 4.5 A bull in good service condition, Marlu Favorite Milestone 579699. Courtesy Maryland-West Virginia Bull Stud

One pound of good quality hay equivalent and one-half pound of concentrates per 100 pounds of body weight, per day, will keep a mature bull in good breeding condition.

The level of nutrition has a marked effect upon the age at which young bulls reach sexual maturity. Bulls raised in a Cornell experiment on three planes of nutrition supplying approximately 60, 90, and 130 per cent of the recommended allowance produced viable semen at 51, 43, and 37 weeks of age, respectively. Young bulls should be separated from heifers at 6 to 8 months of age to prevent unintended conception.

Rate of usage. The ability of bulls to produce satisfactory semen is not as well understood as the egg-producing capacity of cows. There may be considerable individual variation among bulls in this capacity. It is a common practice to start using young bulls at about a year of age. Ten to fifteen services during the first year are frequently recommended. Older bulls are usually used for 40 to 50 services a year.

In artificial insemination many yearling bulls are used weekly and older bulls twice weekly with no apparent detrimental effects. In some instances bulls have been used several times a day for short periods with no observable decrease in semen producing ability.

Housing for bulls. All bulls should be considered dangerous animals and handled as such. Safety pens and stalls are essential. The bull should always be handled with a nose ring. Adequate provisions should be made for sunlight and exercise. Special attention should be given to foot care and trimming. Large bulls should be trained to use a breeding rack to prevent injury to themselves or to cows on which they may be used.

SUMMARY OF PROCEDURES FOR IMPROVING BREEDING EFFICIENCY

1. Maintain and use accurate and complete records on the reproductive history of all animals.
2. Conduct a routine program of pregnancy checks in co-operation with a veterinarian.
3. Conduct a routine program of disease prevention and control with a veterinarian.
4. Check all non-pregnant animals for signs of heat at least twice daily. Pay particular attention to the possibility of silent heats.
5. Breed cows at the first heat 60 days after calving.
6. Breed young animals at the first heat after they reach the weights indicated in Table 4.1.
7. Make sure the quality of semen used is adequate. Check semen from bulls used in natural service.

8. Establish a goal of not over 1.8 services per calf.
9. Maintain adequate nutrition in all animals in the breeding herd.
10. Establish a goal of a calf for each cow every 12 to 13 months.

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5 Artificial Insemination of Cattle

MEN discovered several hundred years ago that living sperm collected from the male and introduced into the female reproductive tract at the proper time would produce a normal offspring. Spallanzani conducted the first recorded research on artificial insemination, with dogs, in 1783. Only slight use was made of this valuable technique until very recent times. Except when given special handling, the life of sperm outside the body is short. The development of an understanding of the physiology of cells in general, and particularly knowledge of the sperm cell, was necessary before artificial insemination could be employed on a practical basis.

The first commercial organization for artificial insemination of cattle in this country started operation in New Jersey in 1938. This operation was based on experience gained from several years of practice in Northern Europe. Since then the practice has spread so that it is available to cattle in the entire country. Over one-third of the dairy calves now born each year are the result of artificial insemination.

Artificial insemination provides dairymen with a number of opportunities to improve efficiency. It makes possible "selected matings" involving outstanding cows and bulls which may be located at considerable distances. Both outcrossing and linebreeding may be practiced more easily.

Probably the greatest contribution of artificial insemination lies in extending the use of outstanding bulls. A sire proven to be a transmitter of desirable characteristics may be mated to thousands of cows. In many instances, service from top quality bulls is much cheaper for the individual dairyman than owning and maintaining a bull himself.

Another benefit of artificial insemination is the proving of bulls used on large numbers of cows with daughters in a wide range of environments. Production information obtained in this way, and properly analyzed, is the most reliable information available on the transmitting ability of bulls.

Several diseases associated with reproduction are more easily controlled or eliminated when artificial insemination is used.

TECHNIQUES USED IN ARTIFICIAL INSEMINATION

Collecting and Processing Semen

The most frequently used system for collecting semen from a bull is the *artificial vagina*. Figure 5.1 contains a diagram of this device. Basically it provides an environment somewhat similar to that of the vagina for the ejaculation of semen and its collection in a test tube.

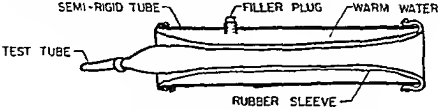


Figure 5.1. Diagram of an artificial vagina, used for the collection of semen from bulls

In use, the bull is encouraged to mount a "teaser" animal in the normal manner. The operator diverts the penis into the artificial vagina where the ejaculate is trapped in the test tube. Bulls exhibit a great deal of individual variation in their response to teaser animals, and operators of bull studs develop a definite art in learning the characteristics of each animal.

The *electro-ejaculator* is sometimes used to obtain semen from older bulls or those unable to mount because of injury. This device consists of electrodes placed in the rectal cavity in close proximity to the reproductive tract and the nerves supplying it. A series of electrical impulses stimulates the ejaculation of semen, which may be caught in a beaker or other container.

Semen should be processed immediately after collection if it is to be used efficiently.

The frequency of collection of semen varies considerably. The most commonly used rate is one collection per week. In a number of operations, bulls are collected two or more times per week with excellent results. There are isolated cases where bulls have been collected many times per day for one or two days without injury. The health, vigor, and age of the bull all play an important part in the frequency of collection which may be used. Current information indicates that collecting yearling bulls once each week and mature bulls twice weekly is not detrimental to semen quality or continued vigor of many bulls.

Evaluation of semen. As produced, there are from 300 million to 2 billion sperm cells per each ml of a normal 5 to 6 ml. ejaculate. Ten million active sperm cells are adequate for one insemination. Dilution is usually made to approximately this level in one ml. of final product.

Fresh semen is examined to determine the total numbers of sperm cells present and the percentage of motility. Total numbers may be determined by actual microscopic count. However, this is a tedious process and a more rapid system is to measure the refraction of light by a sample of semen placed in a device designed for this purpose. The number of sperm cells is inversely proportional to the amount of light passing through the sample.

Motility is usually estimated by direct microscopic observation, which is a rather subjective measurement. Motility of 70 per cent of the cells observed is considered to indicate good quality semen. Figure 4.4, page 80, shows the appearance of sperm under the microscope. At the same time that motility estimates are made, the cells are observed for abnormalities such as crooked tails, broken bodies, missing tails, etc. Large numbers of abnormal sperm indicate the semen will provide a poor rate of conception.

Semen diluters are used to extend the semen to the desired concentration of sperm cells. In commercial practice one ml. of diluted semen containing 10,000,000 or more motile cells is used for each insemination.

Dilutors are designed to provide a satisfactory chemical and physical environment for the sperm cells. All of them contain a buffering agent, to maintain pH at about 6.7 to 6.9, and nutrient material.

The first generally used diluters were based on raw egg yolk. More recently, boiled milk has been used very widely. A number of substances are added to diluters to aid in preservation of the sperm or in conception rate. Certain antibiotics are used routinely to aid in disease control. Glycerol is used in a number of diluters for both fresh and frozen semen. It aids in making possible good conception rates with fresh semen, 3 and 4 days old. The addition of carbon dioxide to semen diluter decreases the activity in the sperm and extends its storage life.

Refrigeration of fresh semen at 40° F. is essential with most diluters. Some exploratory work with new diluters indicates that one may be developed which will not require refrigeration.

The following are two diluters which have been used for semen. In some operations the milk diluter is used for fresh semen and the egg yolk for frozen semen.

No. 1

Homogenized milk	
Pencellin G.	(100,000 units per ml. milk)
Streptomycin	(100,000 units per ml. milk)
Glycerin	(10% by volume)

No. 2

80 ml distilled water
20 ml fresh egg yolk
2.9 gm sodium citrate

When the milk diluter is used, it should be heated to 200° F held for 10 minutes and kept in a sterile condition thereafter When it is cooled to room temperature the antibiotics are added When the milk diluter is to be used it is divided into two equal parts All of the glycerin is added to one part in 3 equal portions at 10 minute intervals Both parts are refrigerated for at least one and one half to two hours before using When the semen is to be added (immediately after evaluation following collection) both portions of the diluter are heated in a water bath to 90° F to be as close as possible to the temperature of the semen The semen is mixed with the portion containing glycerin The second portion of diluter is then added to the partially diluted semen The completely diluted semen is then cooled to 38 to 40° F by placing in a refrigerator After cooling the semen is kept at this temperature until used

The egg yolk diluter is handled in a similar manner except it is not heated Also it should be allowed to stabilize at 38° F for eight hours or longer before the semen is added

Current practices allow the use of fresh semen for up to 4 or more days before conception rate begins to drop off This makes it possible to have fresh semen available every day from a given bull if he is collected twice weekly

Each semen processing business has a number of variations in handling semen but the following is a general description of the technique involved After collection of the semen it is examined for motility and number of sperm cells to establish the possible dilution rate Dilution is usually made with both semen and diluter at 85 to 90° F The diluted semen is then cooled slowly to 40° F by storing in a refrigerator in a water bath Semen should be stored at 40° F for a minimum of 6 hours to allow ample time for antibiotics to be effective

The semen is then placed in labeled vials Many organizations color the semen of each of the breeds with a harmless dye as an aid in identification The semen is shipped in refrigerated containers to the technician or central distribution point where it is used Details of the specific process used are available from most artificial breeding co-operatives

Frozen Semen

For a number of years sperm have been successfully preserved by freezing under carefully controlled conditions Calves have been born from sperm stored for over 9 years in the frozen state A mixture of dry ice and alcohol and liquid nitrogen are two refrigerants used Dry ice and alcohol has a temperature of −79° C or −110° F Liquid nitrogen is at −176° C or −320° F Diluted semen is frozen in one ml ampules which are thawed in cold water preferably ice water just previous to time of service

Special techniques and handling of the semen are necessary during the freezing process to maintain the life of the sperm. After the storage temperature has been reached, warming and cooling of the semen before use endangers the viability of the sperm.

Dried Semen. Successful insemination of a cow under laboratory conditions, using frozen dried semen, has been reported. The procedure, developed by Dr. H. T. Meryman and A. Kafig at the Naval Research Institute, involved dipping a piece of gauze in the fresh semen and placing it under vacuum. Water evaporation was rapid enough so that the water remaining in the sample froze. Evaporation continued until the material was dry. The gauze was then placed in standard semen diluter and viable sperm recovered. The sample was used for inseminating a cow. Refinement of this technique for practical use could add a very useful tool to the management of dairy cattle reproduction. However, much additional work must be done to make this technique useful under practical conditions.

Inseminating the Cow

Figure 5.2 shows the technique of artificial insemination in the female. A gloved hand is inserted in the rectal cavity. The reproductive tract is grasped gently, with care taken not to injure it or the intestinal wall. *A catheter with a squeeze bulb on the end is filled with semen and in*serted in the vagina. By working the catheter and manipulating the cervix with the gloved hand the catheter is moved into the cervix. This is usually possible except in some heifers which have not calved. Semen may be deposited in various places, usually just inside the uterus or in

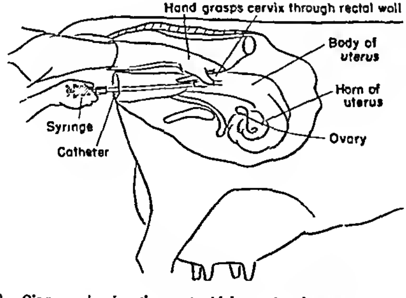


Figure 5.2. Diagram showing the most widely used technique for artificially breeding cattle.

the cervix. Semen is deposited just outside the cervix when it is not possible to penetrate that organ.

EFFECTIVENESS OF ARTIFICIAL INSEMINATION

When good quality semen and proper techniques are used, conception rates with artificial insemination equal or surpass those obtained in natural breeding. Breeding efficiency for this system is commonly reported as 30 to 60 or 60 to 90 day non-returns to service. The figure used is the percentage of animals bred for which a request has not been received for re-breeding. There are, of course, always a number of animals included which do not conceive but for which no request for re-breeding is made. A non-return rate at 60 to 90 days after breeding of 70 per cent is desirable. Several breeding establishments consistently maintain average non-return rates somewhat above this. The non-return rates for individual bulls vary greatly, depending on the quality of the semen they produce.

ARTIFICIAL BREEDING ORGANIZATIONS

A majority of the artificial insemination done in this country utilizes semen from bulls owned or leased by artificial breeding organizations. These may be private business operated for a profit, or they may be co-operative in nature, operated for the service of the members. The latter are more numerous.

In these organizations bulls are kept in a central location, adjacent to laboratory and office facilities, to allow for processing the semen and maintaining proper records. Technicians employed by the breeding organization are stationed throughout the area served by it. Semen is collected from bulls in the stud on a regular schedule. This is established by the stud management, taking into account the public demand for the bull, his semen-producing capacity, and future plans for his use.

Semen is shipped in refrigerated containers to each of the technicians, using whatever means is most efficient in the area served. Dairymen desiring the use of artificial insemination notify the technician, who brings the semen to the farm and performs the breeding. Generally, the technician is responsible for collecting the breeding fee, which, of course, varies with the conditions involved. Current fees average about $6.00 per cow bred. It is the practice of most artificial insemination organizations to provide a second and third service free of charge if the cow does not conceive. Subsequent services are frequently provided at a reduced rate.

Artificial Insemination in Individual Herds

In addition to utilizing the services of breeding organizations, a number of larger operators practice artificial insemination within individual herds where the bull may be present. The advantages of extending the use of bulls, particularly during the heavy breeding season, of disease control, and of the use of bulls unable to mount are available in this system. Semen from outstanding or popular bulls individually owned is frequently marketed for use through artificial insemination.

National Association of Artificial Breeders

Groups in the business of artificial insemination have formed a national organization for the promotion of artificial breeding and for the obtaining and dissemination of technical and business information concerning it. The organization is called The National Association of Artificial Breeders. Its headquarters are at Columbia, Missouri. A monthly paper, the *A.I. Digest*, is published by the organization.

RECORDS IN ARTIFICIAL INSEMINATION

With large amounts of semen from a number of bulls distributed over a wide area, the maintenance of accurate records to identify the sires used in artificial insemination is of great importance to all dairymen. It is an absolute necessity for the purebred breeder.

The identity of semen is carefully preserved by all the breeding organizations. The name or number of the bull is attached to or stamped on the individual container used for each shipment. Many organizations identify the semen of each breed with a harmless dye.

At the time a cow is bred the technician issues a breeding receipt to the owner. This contains the identification of the cow and the sire, and the date, and is certified by the inseminator. A copy of a typical receipt is presented in Figure 5.3.

Regulations Concerning the Use of Artificial Insemination in Purebred Herds

The Purebred Dairy Cattle Association (P.D.C.A.) has developed a set of rules and regulations for the use of artificial insemination of purebred cattle from which calves are to be registered.

They are too detailed to report completely here but may be found in the reference material listed at the end of the chapter. A few points are given here.

115005

BREEDING RECEIPT

Maryland-West Virginia Bull Stud

Date of Breeding __________ Breed of Cow __________

Name of Cow __________

Registry No. __________ Tattoo __________
(Or ear tag if grade)

Was Cow identified by checking registration papers? __________
(Before resulting offspring can be registered cow must be identified by checking registration papers.)

Owner __________

Address __________

Name of Bull __________

__________ Registry No. __________

Was Frozen Semen Used? Yes ____ No ____ Breeding Fee __________

Service Number __________ Date of Previous Service (if any) __________ Bull Used __________

Maryland Artificial Breeding Co-operative, Inc.

I hereby certify that I am a duly authorized agent of the above named business and as such have the authority to issue this receipt which is given as evidence of services rendered and also a certification of date of service and identity of semen used for service of animal identified hereon.

Signed __________
INSEMINATOR

The original copy of this receipt must be given to owner at time of service and must accompany Application for Registry or Birth Report, *unless cow is sold before the calf is born in which case it must be sent to* the breed registry organization with the Application for Transfer of ownership

USE INDELIBLE PENCIL OR INK

Figure 5 3 A typical breeding receipt issued at the time of insemination, meeting the requirements of the *Purebred Dairy Cattle Association* Courtesy Maryland West Virginia Bull Stud and the Purebred Dairy Cattle Association

Registrations of calves resulting from artificial insemination with fresh semen from bulls owned within a herd are handled much the same as with natural breeding. When fresh semen is transferred between herds, special application forms must be completed and filed with the breed association.

Special contracts are required with each semen producing business, and the signature of each approved inseminator must be on file with the breed associations.

A breeding certificate, like the one shown in Figure 5.4, is required when cows are bred by an inseminator representing a semen producing business. The P.D.C.A. and breed associations reserve the right to cancel contracts, or withdraw approval, of any inseminator when evidence indicates the rules are not being properly followed.

Blood typing is required for all bulls owned by semen producing businesses, and for privately owned bulls from which frozen semen is used.

FURTHER READING

Kennelly, J. J., R. S. Hoyt, R. H. Foote, and R. W. Bratton, "Survival Rates of Rapidly Frozen Bovine Spermatozoa," *Journal of Dairy Science*, 43:1140, 1960.

Perry, E. J., *The Artificial Insemination of Farm Animals*, New Brunswick, N. J.: Rutgers University Press, 3rd rev. ed., 1960

The Purebred Dairy Cattle Association, *Requirements Governing Artificial Insemination of Purebred Dairy Cattle*, Peterbrough, N. H.: Purebred Dairy Cattle Association, revised 1960.

6 Developing Dairy Calves and Heifers

TWENTY to twenty-five per cent of the producing animals leave the average dairy herd each year because of low production, disease, poor breeding efficiency, or other reasons. A continuous supply of good-quality replacements is essential if efficient production is to be maintained. Well-grown, healthy heifers are the most desirable source of these replacements. Also, sale of foundation stock to other herds is an important part of the business of many dairy enterprises. Adequate care and management must be practiced throughout the life of all heifers to develop them to their full potential.

The management of the herd replacement begins before the calf is born by providing it with a well-fed, healthy dam selected for ability to transmit the characteristics desired in the mature animal. Use of a sire with the ability to transmit desirable characteristics is equally important.

CARE OF THE CALF AT BIRTH

The calf should be born in a sanitary, dry environment. A sanitized maternity stall is the place of choice in most herds. Where space and season are appropriate, birth on a clean pasture or lot is ideal. At birth the mouth and nostrils should be checked and cleared of any material which may interfere with normal breathing. Also it is desirable to sanitize the umbilical cord and the area where it enters the body with a standard disinfectant

A normal healthy calf should be on its feet and nursing within thirty minutes after birth In extreme weather, the calf may be dried off after birth by rubbing with a cloth. However, the dam does a good job of this under usual conditions. It is a good practice to allow the calf to nurse the dam for the first two or three days. However, when certain calfhood diseases are present within the herd, or if it will make handling more efficient, the calf can be taken from the dam immediately. *Regardless of the practice followed, the calf should be fed colostrum for the first two days*

Housing

The calf is best maintained in an individual pen or stall for the first few weeks. This allows more careful attention to individuals and prevents calves from sucking each other, which may lead to udder difficulties at maturity. After about eight weeks of age, it may be handled with a group. Details on space requirements and structures which may be used during the growing period are given in Chapter 10. In areas where parasites are a particularly serious problem young calves may be housed in individual portable pens which can be moved frequently. This system of housing is used successfully in many sections of the country. It may be helpful in controlling respiratory infections as well as parasites. Simple structures, providing shelter in line with climatic conditions, with most of the floor area made up by the ground, are adequate for these pens.

FEEDING CALVES AND HEIFERS

The feeding program is the most critical factor in the management of the young calf. Nutrient requirements for growing dairy calves and heifers are shown in Table 6.1. This table also includes desirable rates of gain for them. It should be pointed out that the values in Table 6.1 are minimum requirements, and under farm conditions 10 to 15 per cent more energy and protein may be profitably included to allow for variation in feed composition.

Table 6.2 contains information on the nutrient composition of total rations and amounts which when fed daily will supply the nutrient requirements listed in Table 6.1. More details on the kinds and amounts of feeds which may be included in practical rations are considered later in this chapter.

Feeding Young Calves

For convenience, systems of feeding young dairy calves may be divided into four categories. In practice, there are no sharp dividing lines between the systems and many actual feeding programs overlap these categories. They are:

1. Nurse cow.
2. Whole milk or skim milk.
3. Limited whole milk, dry calf starter.
4. Milk replacer, dry calf starter.

TABLE 0 1 DAILY NUTRIENT REQUIREMENTS FOR NORMAL GROWTH OF DAIRY HEIFERS

(Based on air-dry feed containing 90 per cent dry matter)

Body Wgt (lb)	Daily Gain: Small Breeds (lb)	Daily Gain: Large Breeds (lb)	Daily Nutrients per Animal[a]: Feed (lb)	Protein (lb)	Digestible Protein (lb)	TDN (lb)	DE[b] (therm)	Ca (gm)	P (gm)	Carotene (mg)	Vitamin D (IU)
50	0.5	–	0.9	0.31	0.20	1.6	2.6	4	3	2[c]	150
100	1.0	0.8	2.0	0.02	0.46	2.0	4.0	7	6	1	300
150	1.3	1.1	4.0	0.78	0.50	3.0	6.1	12	16	0	450
200	1.1	1.6	0.0	0.94	0.60	1.0	8.1	13	10	8	606
100	1.2	1.8	11.0	1.25	0.80	6.5	13.1	13	12	16	[d]
000	0.8	1.1	15.6	1.33	0.85	8.5	17.1	13	12	21	—
800	1.1	1.2	19.0	1.40	0.90	10.0	20.2	13	12	32	—
1000	–	1.3	22.0	1.48	0.95	11.0	22.2	12	12	46	—
1200	–	1.2	24.0	1.56	1.00	12.0	21.2	12	12	48	—

[a] Thiamine, riboflavin, niacin, pyridoxine, pantothenic acid, folic acid, vitamin B_{12}, and vitamin K are synthesized by bacteria in the rumen, and it appears that *adequate amounts* of these vitamins are furnished by a combination of rumen synthesis and natural feedstuffs Manganese, magnesium, iron, copper, and cobalt are essential, and the amounts needed are discussed in the text

[b] DE (digestible energy) was calculated on the assumption that one gram of TDN has 4.4 kcal of digestible energy (2,006 kcal/lb), a value based largely on the extensive summary of published data made by *B H Schneider* *D E. may* be converted to metabolizable energy by multiplying by 82 per cent

[c] Calves should receive colostrum the first few days after birth, as a source of vitamin A and other essential factors

[d] While vitamin D is known to be required, the data are inadequate to warrant specific figures for older growing animals

Taken from *Nutrient Requirements of Dairy Cattle* National Research Council Revised 1958

TABLE 6 2 NUTRIENT CONTENT OF RATIONS FOR DAIRY HEIFERS

(Based on air dry feed containing 90 per cent dry matter)

Body Wgt (lb)	Average Age: Small Breeds (months)	Average Age: Large Breeds (months)	Total Daily Feed (lb)	Feed % of Wgt (%)	Per Cent of Ration or Amount per Pound of Feed: Digestible Protein (%)	TDN (%)	DE [a] (therms/lb)	Ca (%)	P (%)	Carotene (mg /lb)	Vitamin D (IU/lb)
50	Birth	—	0 9	1 8	22 0	110	2 22	0 98	0 73	—	170
100	2.3	0 0	2 0	2 0	20 0	100	2 02	0 77	0 08	2 0	150
150	3 7	2 0	4 0	2 7	12 5	75	1 52	0 66	0 44	1 5	110
200	4 8	3 1	6 0	3 0	10 0	67	1 35	0 48	0 40	1 3	100
400	10 0	6 7	11 0	2 8	7 3	59	1 19	0 20	0 30	1 5	—
600	17 2	10 8	15 0	2 7	5 7	57	1 15	0 19	0 22	1 6	—
800	28 0	10 0	19 0	2 5	4 7	53	1 07	0 15	0 15	1 7	—
1000	—	22 0	22 0	2 2	4 3	50	1 01	0 13	0 13	1 8	—
1200	—	36 0	24 0	2 0	4 2	50	1 01	0 12	0 12	2 0	—

[a] DE (digestible energy) may be converted to metabolizable energy by multiplying by 82 per cent

Taken from *Nutrient Requirements of Dairy Cattle* National Research Council Revised 1958

The systems above are listed in order of increasing demand for management skill in raising calves With good sanitation little other management is needed when calves are raised on a nurse cow Considerable attention and skill are needed for the last system Where market milk is sold, the systems listed are in decreasing order of feed cost. In situations where milk is sold for manufacturing purposes, the milk replacer system is frequently uneconomical

Regardless of what system is used, the newborn calf should receive colostrum, preferably by nursing the dam, for the first 48 hours The most important contribution of colostrum lies in antibodies associated with the globulin fraction of the protein The blood of the newborn calf has practically no antibodies and it is essential that the calf obtain them if it is to survive against several diseases, particularly those creating symptoms in the digestive system It is also important that colostrum be given early to the calf, since after two days of life it loses the ability to absorb antibodies through the intestinal wall.

In addition to antibodies, colostrum is high in total protein, it supplies extra amounts of vitamin A (if the cow is consuming adequate carotene) and it contributes a laxative effect If for any reason colostrum from the dam is not available, every effort should be made to obtain it from other sources Excess colostrum may be frozen and stored for emergencies

Use of nurse cows Probably the easiest way to raise calves is to allow three or four of them to nurse a cow Calves should be taught to eat hay and a calf starter (a grain mixture designed to meet the needs of growing calves) before weaning. Calves may be carried on this system for as long as six months, or they may be weaned at two or three months Care should be taken to adjust the number of calves to the production of the cow

If the calf is weaned at two or three months, it should be eating at least two pounds of a calf starter per day and appreciable amounts of good-quality hay at that time, if it is to maintain reasonable growth. At this age up to four pounds of calf starter per day may be fed if the calf will consume it.

Raising calves on whole or skim milk. When the calf is removed from its dam, it may be fed by teaching it to drink, or the milk may be given in a nipple pail Milk of moderate to low fat test tends to reduce the chance of digestive upsets The rate of milk feeding should be about 10 per cent of the calf's weight per day, up to a maximum of ten to twelve pounds per day This should be divided into at least two feedings a day If there is any question of digestive upsets, underfeeding is more desirable than overfeeding. If scouring occurs the milk allowance should be reduced to one-half or less until the calf recovers

Cleanliness and sanitation are absolutely essential for all utensils

used in feeding calves. It is usually recommended that milk be fed at a constant temperature each day, preferably at 95° to 100° F. However, under conditions of good sanitation and low incidence of disease, calves can tolerate considerable variation in feeding conditions.

If skim milk is readily available, it may be gradually substituted for whole milk as the calf reaches two or three weeks of age. Because of its lower fat and energy content, it is usually recommended that about 25 per cent more be fed than when whole milk makes up the ration. Older calves may be fed all the skim milk they will consume if they are gradually accustomed to it.

If milk supplies are plentiful, calves may be continued on it for up to six months of age or longer. However, they may be weaned to grain and hay any time after two and one-half to three months. Feeding from this period on may be handled as described below.

Raising calves on limited whole milk and dry calf starter. Under this system calves may be raised successfully with amounts of whole milk varying from 175 to 400 pounds. The advantage of this system is in the substitution of cheaper nutrients in grain and hay for those in milk. Calves raised under this program may not be as smooth or grow quite as fast during the first few weeks. However, by 18 months of age there should be little difference.

The calf should be fed colostrum and taught to drink as mentioned previously. A sample milk-feeding schedule is presented in Table 6.3. This may be varied within the limits of total milk mentioned above. The thriftiness of the calf should be considered, with weaker calves receiving milk for a longer period than strong, well-grown ones. By the beginning of the second week, a dry calf starter and hay should be fed.

TABLE 6.3. SUGGESTED MILK FEEDING SCHEDULE

For Calves Raised on the Limited Whole Milk Dry Calf Starter Method

Age	Daily Allowance of Milk: Large Breeds (pounds)	Daily Allowance of Milk: Small Breeds (pounds)
1 – 3 days	colostrum	colostrum
4 – 7 days	8	5
2nd week	9	6
3rd week	10	7
4th week	8	7
5th week	6	6
6th week	5	5
7th week	3	4
8th week	–	3
9th week	–	3

Dry calf starter. The calf may be introduced to the starter by placing a small amount in its mouth following the feeding of milk. A small amount put into a feed box each day will induce the calf to eat regu-

larly. Calf starter may be fed on a free choice basis up to a maximum of three and one-half to four pounds per day. Calves should be consuming this amount by about three months of age. If especially rapid growth is desired more grain may be fed.

A great variety of calf starters are available commercially which provide adequate nutrition. When excellent-quality hay and good management are available, calves will perform satisfactorily on a simple grain mixture or the mixture fed the milking herd If a simple mixture is used, calves should have access to sunlight or other adequate sources of vitamin D. Sample formulas for two types of calf starters are given in Table 6 4. If a complex starter is used, it should be replaced by a simple mixture, or the herd ration, at about four months of age.

TABLE 6.4. GRAIN MIXTURES FOR YOUNG CALVES.

Ingredient	Starter Mixture (lbs.)	Simple Mixture (lbs)
Ground or cracked, shelled corn and/or barley	820	770
Oats	400	400
Wheat bran	300	300
Soybean meal	250	400
Linseed meal	200	—
Alfalfa leaf meal	100	100
Cane molasses	100	—
Antibiotic (tetracycline type)	20 (grams)	
Irradiated yeast	20.5	—
Dicalcium phosphate or steamed bone meal	20	20
Iodized salt	10	10
	2000.5	2000

Because young calves chew their grain well, whole corn or oats may be included in the ration for the first four to six months. Other harder grains should be cracked. All grains should be ground for older animals.

Hay. The best-quality hay available should be used for young calves. Leafy, fine-stemmed legume hay is most desirable. However, good-quality mixed hay or early-cut grass hay may be used satisfactorily. Fresh hay should be provided daily starting at two weeks of age The calf may be allowed all the hay it will consume, unless it is in short supply or overly expensive

Calves should be handled as indicated on the limited milk-dry calf starter method, except for the substitution of the milk replacer for most of the milk. While the saving in milk may be important, the cost for labor and management will be greater than in a program utilizing whole milk.

Calf-raising programs which call for emphasis on grain with limited hay intake, and those which rely heavily on hay with only a small amount of grain, have both been successful when properly managed. The first system emphasizes the use of high-energy feeds, and allows rapid growth during the early weeks. The latter method depends upon the rapid development of rumen function and the ability to utilize roughage early. The decision as to which method to use should be based upon the availability and cost of grain and high-quality hay, and the degree of management available for the calf herd.

Antibiotics for calves. An increased growth rate has been shown when young calves are fed certain antibiotics. They also reduce the incidence of scours. Advantages in growth rate are limited to the early weeks, and heifers not fed antibiotics catch up quickly. Unless management conditions are better than average, the feeding of broad-spectrum antibiotics such as the tetracyclines will probably pay off in reducing disease and mortality. The usual rate is about 15 to 20 mg. per 100 pounds live weight per day. Antibiotics are of most benefit to the younger calves and may be added to the milk fed to them. Milk replacers and calf starters may also be used as vehicles for antibiotics. Including antibiotics in the feed should not be used as a substitute for good management and sanitation.

Cud inoculations for calves. When the feeding program includes high amounts of forage, it has been suggested by some research workers that cud material be taken from a ruminating cow and fed to the young calf. This is to establish the microflora more rapidly in the rumen. Calves in extreme isolation apparently benefit from this, but research has indicated that under most farm conditions normal rumen bacteria become established quickly without inoculation.

Silage for calves. Good-quality silage may be substituted for all or part of the hay in the calf ration under certain conditions. Calves will usually not eat as much dry matter in the form of silage as in the form of hay. More grain should be fed when silage makes up the only forage. Silage may be fed as part of the forage, with hay fed free-choice in addition.

Recommended Feeding Practices Following Weaning

If the calf is weaned at six to eight weeks, it should be eating at least two pounds of starter per day as well as appreciable amounts of hay at

larly Calf starter may be fed on a free choice basis up to a maximum of three and one half to four pounds per day Calves should be consuming this amount by about three months of age If especially rapid growth is desired more grain may be fed

A great variety of calf starters are available commercially which provide adequate nutrition When excellent quality hay and good management are available, calves will perform satisfactorily on a simple grain mixture or the mixture fed the milking herd If a simple mixture is used, calves should have access to sunlight or other adequate sources of vitamin D Sample formulas for two types of calf starters are given in Table 6 4 If a complex starter is used, it should be replaced by a simple mixture or the herd ration, at about four months of age

TABLE 6 4 GRAIN MIXTURES FOR YOUNG CALVES

Ingredient	Starter Mixture (lbs)	Simple Mixture (lbs)
Ground or cracked shelled corn and/or barley	820	770
Oats	400	400
Wheat bran	300	300
Soybean meal	250	400
Linseed meal	200	—
Alfalfa leaf meal	100	100
Cane molasses	100	—
Antibiotic (tetracycline type)	20 (grams)	
Irradiated yeast	20.5	—
Dicalcium phosphate or steamed bone meal	20	20
Iodized salt	10	10
	2000.5	2000

Because young calves chew their grain well whole corn or oats may be included in the ration for the first four to six months Other harder grains should be cracked All grains should be ground for older animals

Hay The best quality hay available should be used for young calves Leafy, fine-stemmed legume hay is most desirable However, good quality mixed hay or early-cut grass hay may be used satisfactorily Fresh hay should be provided daily starting at two weeks of age The calf may be allowed all the hay it will consume, unless it is in short supply or overly expensive

Variations on the limited whole milk-dry calf starter method Milk replacers have been developed which may be used to replace all but 50 to 60 pounds of whole milk in the calf feeding program The most successful of these are based on milk or milk by products Milk replacers are usually designed to be mixed with water and fed in a manner similar to milk Although calves may not be quite as thrifty in early life with this method satisfactory results may be obtained when a good quality milk replacer is fed according to directions supplied with the product

Calves should be handled as indicated on the limited milk-dry calf starter method, except for the substitution of the milk replacer for most of the milk. While the saving in milk may be important, the cost for labor and management will be greater than in a program utilizing whole milk.

Calf-raising programs which call for emphasis on grain with limited hay intake, and those which rely heavily on hay with only a small amount of grain, have both been successful when properly managed. The first system emphasizes the use of high-energy feeds, and allows rapid growth during the early weeks. The latter method depends upon the rapid development of rumen function and the ability to utilize roughage early. The decision as to which method to use should be based upon the availability and cost of grain and high-quality hay, and the degree of management available for the calf herd.

Antibiotics for calves. An increased growth rate has been shown when young calves are fed certain antibiotics. They also reduce the incidence of scours. Advantages in growth rate are limited to the early weeks, and heifers not fed antibiotics catch up quickly. Unless management conditions are better than average, the feeding of broad-spectrum antibiotics such as the tetracyclines will probably pay off in reducing disease and mortality. The usual rate is about 15 to 20 mg. per 100 pounds live weight per day. Antibiotics are of most benefit to the younger calves and may be added to the milk fed to them. Milk replacers and calf starters may also be used as vehicles for antibiotics. Including antibiotics in the feed should not be used as a substitute for good management and sanitation.

Cud inoculations for calves. When the feeding program includes high amounts of forage, it has been suggested by some research workers that cud material be taken from a ruminating cow and fed to the young calf. This is to establish the microflora more rapidly in the rumen. Calves in extreme isolation apparently benefit from this, but research has indicated that under most farm conditions normal rumen bacteria become established quickly without inoculation.

Silage for calves. Good-quality silage may be substituted for all or part of the hay in the calf ration under certain conditions. Calves will usually not eat as much dry matter in the form of silage as in the form of hay. More grain should be fed when silage makes up the only forage. Silage may be fed as part of the forage, with hay fed free-choice in addition.

Recommended Feeding Practices Following Weaning

If the calf is weaned at six to eight weeks, it should be eating at least two pounds of starter per day as well as appreciable amounts of hay at

that time. Hay should be continued free-choice. Starter should be fed free-choice until the calf is eating three and one-half to four pounds per day. At the age of four months, a simple grain mixture or the herd ration may replace the calf starter, if a complex mixture or commercial feed has been used. Recommended levels for concentrate feeding can be derived from Table 6.2, based upon the size of the calf and the quality and amount of forage consumed. Feeding higher levels of concentrate may be practiced if faster growth is desired.

Throughout the growing period, forage should be supplied free-choice. As the heifer approaches calving, care should be taken that enough nutrients are supplied to support pregnancy. High production will generally be achieved with less feed if cattle are well-grown and in good flesh at calving time. Samples of rations which will provide adequate nutrition for growing heifers are included in Table 6.5.

Pasture for growing heifers. Calves six to eight months of age will obtain many nutrients from pasture but should be supplied additional hay and grain. At about the age of one year, heifers can live entirely on good-quality pasture with supplemental salt and an ample supply of water. Care should be taken that there is adequate forage available. If pastures dry up or are in short supply, supplementary forage or grain should be fed.

Growth standards for heifers. Table 6.2 contains average growth rates and weights at specific ages for dairy heifers. In some herds, feeding for faster growth and early breeding may be desirable and provide an economic advantage. Care should be taken to prevent heifers from becoming overly fat, which frequently is accompanied by excessive fat deposition in the udder. This interferes with normal development of secretory tissue and results in lowered milk production.

Good management of growing heifers includes frequent checking of growth progress and adjusting feed accordingly. If facilities for weighing are not available, weight can be estimated by measuring the heart girth with a tape especially designed for this purpose.

MAINTAINING HEALTHY CALVES AND HEIFERS

The principles of a good health program discussed in Chapter 10 apply to young animals. A few diseases and disorders of particular importance to calves are discussed here.

Calf Scours

Difficulty involving the digestive tract of calves, resulting in diarrhea, or *scours*, is probably the most serious problem in calf raising. The cause

TABLE 6 5 EXAMPLES OF ADEQUATE RATIONS FOR GROWTH [a]

	Total Feed (lb)	Digestible Protein (lb)	TDN (lb)	DE [b] (therms)	Calcium (gm)	Phosphorus (gm)	Carotene (mg)
100 pound calf							
Nutrient requirements	–	0 40	2 0	4 0	7	6	4
Ration in pounds							
Whole milk, 12 0	–	0 40	1 94	3 9	0 5	3 4	–
400 pound heifer							
Nutrient requirements	11	0 80	6 5	13 1	13	12	16
Ration in pounds							
A Mixed clover timothy hay, 8 0, yellow corn, 1 0, oats 1 0, linseed meal, 1 0	11	0 85	0 4	12 9	29	10	72
B Legume hay, 10 0, yellow corn, 2 0 (oats or barley)	12	1 73	6 6	13 3	67	13	117
600 pound heifer							
Nutrient requirements	15	0 85	8 5	17 2	13	12	24
Ration in pounds							
A Mixed legume-grass hay, 10 0, oats, 5 0 (corn or barley)	15	0 90	8 5	17 2	30	12-15	90
B Alfalfa hay, 15 0	15	1 58	7 0	15 4	100	16	170
C Timothy hay, 10 0, barley, 5 0, limestone, 0 05	15	79	8 8	17 8	20	20	53
D Alfalfa hay, 10 0, corn silage, 15 0	25	1 23	7 8	15 8	73 5	15	210

[a] Taken from National Research Council Nutrient Requirements of Dairy Cattle Publication 464 Revised 1958
[b] DE (digestible energy) may be converted to metabolizable energy by multiplying by 82 (82 per cent)

of most calf scours is unknown, but because of the characteristics of many outbreaks, and measures which are helpful in control, it appears to be infectious in nature. It is likely that viruses are involved. The feeding program may have a contributory or causative effect in some cases. Coccidiosis and other parasitic infections also result in scours. The death of calves or prolonged periods of unthriftiness and poor growth result. Some animals never do reach normal development as a result of scours.

Scours are frequently differentiated according to their severity and the characteristics of the diarrhea involved. Whether these differences represent actual differences in infections is not known. "White scours," for example, is the term given to a diarrhea which is loose, light-colored, and with a foul odor. This usually occurs in the first few days of life. Severe scouring may occur without discoloration of the feces.

The progress of scours in very young calves may be rapid, with death occurring a few hours after symptoms are first observed or within two or three days. Mortality can be high in serious infections. In addition to diarrhea, affected calves exhibit depression, lack of appetite and evidence of dehydration.

The treatment for scours is the use of sulfa drugs or antibiotics or combinations of them. Antibiotics of the tetracycline spectrum have proved most effective. Feeding should be limited.

Colostrum from the dam or another fresh cow is essential to provide the newborn calf with antibodies against agents causing scours. Because of changes in the digestive tract of the calf, the ability to absorb antibodies is lost fairly rapidly. Colostrum is most effective during the first 24 hours of the life of the calf. It is relatively ineffective after 48 hours.

Maintaining strict sanitation in the area where the cow calves and where young calves are housed is of extreme importance. Adequate feed intake without overfeeding is important. Sudden marked changes in the quantity and quality of feed should be avoided where scours is a problem. While not a substitute for good management, the routine feeding of antibiotics in the milk, milk replacer, or calf starter is helpful. These may be supplied at the rate of 20 milligrams per 100 pounds of body weight.

At times very acute infections of calf scours are present in a herd. Death occurs early in life and no treatment is effective. In this situation it may be necessary to isolate newborn calves as quickly as possible after birth in quarters as nearly sterile as possible. Colostrum should be provided, but, to avoid picking up the infection from the dam, the calf should not be allowed to nurse. Under these conditions, the maternity pen should be thoroughly sanitized before each cow is brought in. Most calves can be saved if thorough sanitary precautions and effective iso-

lation are practiced, and the calf is fed carefully, with antibiotics in the feed.

In some instances, blood transfusions from mature animals have been utilized to give the calf immune bodies quickly as protection against severe scours.

Respiratory Diseases of Calves

Like most other animals, calves are susceptible to respiratory infections which may have the appearance of the common cold or the more serious conditions of pneumonia. Pneumonia often accompanies, or appears as a complication of, scours. It can be rapidly fatal.

Again, the causative agents are not known; however, research is indicating that cattle are probably affected by a number of viruses which result in cold symptoms. The way these infections are acquired is not well understood. Stress on an animal may be involved, making it susceptible to the action of infectious agents which are continuously present. Some evidence exists to indicate that waves of infection pass through a herd, started by new animals in a herd or other outside contacts.

Prevention includes, as usual, the practice of good sanitation and the elimination of contact or traffic between herds or groups of cattle.

Good ventilation is extremely important. Confinement of calves in humid quarters, barns, or pens subject to sudden changes of temperature or drafts should be avoided. All of these appear to place stress on calves, making them more subject to respiratory illnesses. Housing of the type shown in Figures 11.3 and 11.6, pages 190 and 194, is recommended.

GENERAL MANAGEMENT OF CALVES

Identification

All calves should be permanently identified as soon as possible after birth. An ear tag system is most satisfactory. Without permanent identification, the parentage and other information on calves is frequently lost.

Obviously, in addition to marking the calf, adequate records must be kept. Tattooing identifying numbers on the ear of lighter or solid-colored calves, and making color sketches of animals of mixed color, are the most satisfactory methods of identifying cows for record-keeping. Where purebred cattle are involved the system required by the registry association should be followed. Application for registry should be made immediately.

Dehorning

Dehorning should be practiced on all calves. Horns on cattle are a source of injury to animals in the herd and people working with them. In years past, horns have had interest in the show ring, but this is no longer the case.

Dehorning may be accomplished by burning with an iron designed for the purpose, or by removing surgically with special tools or by destruction with a strong caustic. Each of the methods should be applied when the calf is only a few weeks old. Specific procedures should be followed according to the directions for the equipment used or as prescribed by a veterinarian.

Removal of Extra Teats

Teats on the udders of heifers in excess of four are usually best removed. Frequently, limited amounts of milk may be secreted by extra teats, creating difficulty at milking time. It is important in removing supernumerary teats to be positive that it is an extra one being removed and not one of the four which would normally become functional.

Extra teats may be removed by a veterinarian or by an experienced herdsman who makes sure proper sanitary procedures are followed and that the correct amount of tissue is removed. An opportune time to remove extra teats is when the calves are being vaccinated for brucellosis.

COST OF RAISING HEIFERS

In a majority of cases the total cost of raising replacement heifers is remarkably close to the market value of an animal ready to calve for the first time. Because of wide variation in prices in different areas and fluctuations from year to year, it is not possible to give specific figures for the cost of raising replacement heifers. The following is a list of the items which should be carefully evaluated in a calf-raising program.

1. Value of calf at birth.
2. Value of feed consumed, including milk, milk replacer, calf starter, growing ration or herd mix, hay, pasture, and silage.
3. Labor.
4. Bedding.
5. Veterinary services and medication.
6. Depreciation and taxes on buildings and equipment.
7. Taxes on the animal
8. Interest on original investment and continuing investment in feed, labor, and so forth

Return from the heifer during the growing period is limited to the value of the manure she produces.

There is a growing interest in raising calves commercially. In some large herds maintained for intensive milk production, there is frequently little attention given to raising replacements. Calves may be purchased from these herds at birth and sold when they are ready to start milking.

RAISING CALVES FOR VEAL

Bull calves and females not designated to be raised for replacements are sold for meat. These may be sold when one or a few days old or fed intensively to the age of approximately six weeks and then sold.

The traditional method of raising veal has been to allow the calf to nurse all the milk it would consume until it reaches a weight of about 200 pounds or more. No other feed is supplied. This produces a carcass which is very white and has had greatest market value.

In areas where milk prices are low, or where cows are available for nursing, raising veal in this manner may be a profitable venture. When a ready market is available, milk usually provides a greater return than veal.

Recently, milk replacers have been developed which make possible rapid growth of young calves. These are usually based on dried milk products and a stabilized fat. Many people have successfully raised veal on milk replacers on an experimental basis, and success has been achieved in some commercial operations. The labor and management efforts involved frequently make this system rather impractical when only a few calves are raised in conjunction with a milking operation. Some operators have attempted to develop a veal business by buying bull calves from various sources and feeding them out in a central location.

Disease is the major difficulty in this enterprise. When numbers of calves are assembled from several sources, scours and other diseases frequently reach epidemic proportion quickly, with a high percentage of mortality. Antibiotics, sulfa drugs, and careful sanitation can do much to counter the disease problem. A few carefully managed units are making a success of feeding large numbers of veal calves. However, the disease problem remains an ever-present threat. With increased knowledge of the specific problems involved, veal raising on a commercial basis may become a profitable adjunct to the business of dairying.

In some areas, markets which accept calves partially fed on grain and a milk replacer may be developed. A few calves have already found this type of market on an experimental basis.

FURTHER READING

Harrison, H. N., R. G. Warner, E. G. Sander, J. K. Loosli, S T. Slack, and K. L. Turk, "Relative Growth and Appearance of Young Dairy Calves Fed Two Levels of Milk With a Simple or Complex Calf Starter," *Journal of Dairy Science*, 43.1084, 1960

Noller, C H., M. C. Stillons, B. W. Crowl, N. S Lundquist, and A. L. Delez, "Pasture for Young Dairy Calves," *Journal of Dairy Science*, 42.1592, 1959

Sander, E. G, R G. Warner, H. N. Harrison, and J. K. Loosli, "The Stimulatory Effect of Sodium Butyrate and Sodium Propionate on the Development of Rumen Mucosa in the Young Calf," *Journal of Dairy Science*, 42.1600, 1959.

Swanson, E. W., "Effect of Rapid Growth With Fattening of Dairy Heifers on Their Lactational Ability," *Journal of Dairy Science*, 43:377, 1960.

7 Records for Dairy Cattle

A satisfactory dairy enterprise must pay all costs of production and provide for an adequate profit or management income to the operator. Highly efficient operation is necessary if this objective is to be achieved. Costs of feed, labor, depreciation, bedding, and interest on investment are major areas of expense in a milk-producing business. Insurance, taxes, veterinary fees, and a number of other expenses must also be provided for. Accurate records of the cost of all items, and of the amount and value of production are necessary if sound management decisions are to be made.

Since each cow is in reality an individual production unit, detailed records on its production and consumption are necessary to evaluate its usefulness. The market value of individual cows depends to a large extent upon their demonstrated ability for milk production. Therefore, it is important that milk production be recorded in a manner which leaves the record free of any possible bias due to personal interest.

A number of production record systems have been developed. Both the breed registry organizations and the federal and state research and extension services sponsor programs. Close co-operation between these two groups exists in several states. All of these programs have been approved by the American Dairy Science Association.

NATIONAL COOPERATIVE DAIRY HERD IMPROVEMENT PROGRAM

The Dairy Husbandry Research Branch, Agricultural Research Service of the United States Department of Agriculture, working in co-operation with the dairy portion of the extension program in each state, makes available to dairymen a series of programs in production testing. Some of the details of each are presented below. Complete information is available from the College of Agriculture at your state university. Inquiries should be directed to the Supervisor of Production Testing, care of the Dairy Department, if you wish to initate a testing program in your herd.

MONTHLY REPORT DHIA 200

DAIRY HERD IMPROVEMENT RECORD

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
DAIRY CATTLE RESEARCH BRANCH AND
STATE AGRICULTURAL EXTENSION SERVICES COOPERATING

Type of record and feed code			Center ing day	Date tested Mo	Day
DHIA					
St	Co	H rd no			
42	85	0027	20	1	21

JOHN B LONG
ROUTE 3
AMES IOWA

Page no	Mo	Day	Mo	Day	From Mo	Day	To Mo	Day	Yr
	1	22	1	26	1	05	2	04	0

Herd data	Av body cwt	Number cows	Days in milk	Days milked 3X	Milk	% test	Fat	Concentrates fed	Succulents fed	Dry roughage fed	Pasture	Feeding index	Rate of roughage	Value of product	Cost concentrates	Feed cost	Income over feed cost	Feed cost per cwt milk $	Number of workers	1000 lbs. of milk per worker	$100 return above feed cost per worker
Test day	—	16	83		34.4	3.8	1.3	9 / 36	40 / 26	18 / 38			2.4	1.33	.21	.48	.85				
12 mo herd totals					1809		616	524	970	662	268			569	111	257	312				
12 mo. avg. per cow	13	13.4	87		10450	3.9	400	34 / 34	63 / 18	43 / 27	174 / 21	107	2.3	370	72	139	231	1.33	.5	321	62

Breed	Registration or eartag number of cow	Status Code	Status Mo	Status Day	Daily milk wt (lbs)	% test	Concentrates fed lbs	Concentrates lbs per cwt	Barn name	Cow index number	Current test period: Days in milk	Milk lbs	Fat lbs	Age at calving (mo)	Body cwt	Number days: Dry	Calf to calf	Milked 3X	In milk	Lactation to date: Milk pounds	% test	Fat pounds	Value of product $	Income over feed cost $	Cond. abn. rec.
3	3025784	1			290	4.5	8	5	9	9	31	900	41	177	12	81	167		243	10060	4.3	431	443	311	
3	3742388	1			537	3.8	8	13	26	26	31	1660	63	94	15	52	111		199	10600	3.6	381	390	286	
3	3765686	4	12	21	495	3.7	10	13	DUCHES	28	31	1530	57	74	13	31	46		106	6750	3.6	242	247	189	
3	4166888	0							AMY	42				73	14	47	[illegible]		305	10800	4.0	436			#
		1			276	4.2	8	5			31	660	36	73	[illegible]	[illegible]	[illegible]		327	11410	4.0	461	461	306	
3	4136859	0							BELLE	44				[illegible]	[illegible]	[illegible]	198		274	10530	4.3	454			¤#
		5	1	4			2	4						61	13	31	229		274	10530	4.3	454	462	307	2¤
3	4136861	1			418	3.9	8	7	SUSAN	45	31	[illegible]	[illegible]	59	12	49			854	4190	4.2	177	178	135	
3	42WAG5637	1			295	3.3	13	6	OPAL	[illegible]	[illegible]	[illegible]	30	49	14	62	226*		303	10010	4.0	404	413	267	1
3	420AE1992	3					5	4	SPOT	[illegible]				31	14	113	210		478	17930	4.1	707	702	455	

SPECIMEN COPY

3	42XAB1634	0							PMROS	49				40	14	53	283		359	15200	3.6	546	552	348	□
		2	12	31	626	4.1	12	16			33	2070	85	53	15	53			33	2070	4.1	85	74	061	
3	4467794	1			373	3.4	8	7	MARY	51	31	1170	40	39	14	55	86		146	6780	3.9	264	270	196	5
3	4635319	1			463	3.4	8	11	8 ETHL	52	31	1450	49	26	12				97*	4340	3.5	153	157	114	
3	4635320	1			525	3.6	12	15	GRACE	53	31	1630	59	25	10				90*	4500	3.8	169	171	131	
3	4513970	1			466	3.5	8	12	SALLY	54	31	1440	50	31	11				69*	2650	3.8	100	104	078	7
3	4727343	4	1	20	508	3.0	10	11	MYRT	56	31	1570	47	26	11		16		63	3530	3.5	122	121	095	
3	4445643	7	12	25			5	7	HAZEL	57					14									-019	
3	4169797	7	1	10	225	3.9	13	6	SMITH	58	26	590	23		13				26	590	3.9	23	22	010	
3	42XAB3971	2	1	18			10	4	EMBLEM	59				25	12									-008	9

BREED CODE
1 Ayrshire 5 Brown Swiss
2 Guernsey 6 Milking Shorthorn
3 Holstein 7 Red Dane
4 Jersey 8 Other
9 Red Poll

STATUS CODE
1 In Milk 5 Left Herd
2 Calved 7 Entered Herd
3 Dry 8 Aborted
4 Bred

□ DENOTES LESS THAN 12 MONTHS PERIOD

● MILKED 3X THIS TEST PERIOD

* COWS NEED TO BE DRIED OFF AT 220 DAYS OF PREGNANCY IN ORDER TO HAVE A 60-DAY DRY PERIOD

● COW IN MILK MORE THAN 60 DAYS. BREED COWS 60 TO 90 DAYS AFTER FRESHENING FOR NORMAL (12 TO 13 MONTH) CALVING INTERVAL

CONDITIONS AFFECT NG RECORD
1 Estimated
2 Sold for Dairy
3 Died or Sold for Beef
4 Injury
\# 305 Day lactation
5 Mastitis
6 [illegible]
7 Other Sickness
8 Abortion
9 Nurse Cow
□ Complete lactation

Figure 7.1. The type of information reported to the herd manager each month from an electronic data processing center.

Dairy Herd Improvement Association (DHIA)

The Dairy Herd Improvement Association (DHIA) system is the most used system of dairy record-keeping. This program works as follows.

A supervisor or tester employed by the local testing association visits the herd one day each month He identifies all cows in the herd, weighs and takes representative samples of the milk from all animals in the herd for two consecutive milkings (from three milkings for herds on 3× milking). He then combines the milk samples and tests them for butterfat. (In many associations, this testing is done in central laboratories.) Records are also obtained on the amount of grain fed each cow, and roughage consumption is calculated on a herd basis. Additional information on breeding dates, calving dates, dry dates, and other factors affecting the cow's productivity is recorded. Cost or value data are obtained on feed used and milk or other products sold.

Calculations are made, and information recorded, on production for individual cows and for the entire herd. Feed costs and income for each cow are calculated and reported A considerable amount of other information is also recorded by the tester in a permanent herd book for use by the dairyman. As each cow completes a lactation, summary information is recorded. At the end of the testing year, a herd average and summary are calculated

The supervisor submits his reports to the county agricultural agent and the state supervisor of testing, who are responsible for approving them. When properly used, this system of record-keeping provides the herd manager with rather complete information on his herd. In addition, reports submitted by the supervisor to the state and federal agencies co-operating in the program supply a reliable source of research material on the dairy industry. It is from these reports that bull proofs are developed

Records produced in this manner are approved by the state supervisor of production testing and may be published as representing the performance of a given cow or herd.

Use of Electronic Data-Processing Machines. Electronic data-processing machines have been adapted to processing records obtained by the supervisor. In this program, the supervisor obtains all of the data and mails them to a processing center. Here the data are submitted to the machines for calculation and summarization. The dairyman then receives a permanent record sheet each month from the computing center A sample copy of this sheet is shown in Figure 7.1. A few programs provide somewhat different information, but the one presented is used in most states. Present trends indicate that electronic data-processing machines will be used for most of the DHIA records in the near future.

The following material is in explanation of the information available to a herd manager from records of the type shown in Figure 7.1.

Monthly Herd Summary. The first line of figures running across the page carries information based on the daily average per cow, in other words, the average cow's performance on the day of the month on which the herd was tested. These data give a month-to-month comparison on the performance of the herd.

One of the few concepts of the central processing system is the computation of the percentage of net energy [%N.E.] furnished by each of the major feed sources. The amount of net energy is based upon the nutrient content of the various feeds, according to the amounts and quality reported by the supervisor on the barn sheet.

The rate of roughage feeding is computed from the amount fed, compared to the average body weight, and is quoted in terms of "hay equivalent" fed per hundred pounds of body weight. A set of factors is used to convert pounds of silage, inferior quality hay, or pasture hays to their equivalent weight in good hay.

The third line down is a "12-month herd average" which will be shown each month. It will include all data since the herd was started on central processing. Thus, on first month's sheet it is an "annual average" based on only one month's data. Next month, the first 2 months' information will be averaged, and so on, until at the end of 12 months a legitimate yearly figure will be available. After that, this computation will always include the previous 12 months, so a "rolling herd average" will be established. The comparison of this rolling herd average to individual cows' records at any time will provide a useful means of evaluating a cow's production record, because each cow can then be compared with her stable-mates over a similar length of time.

The "feeding index" is a percentage computation, obtained by dividing the amount of net energy received by the amount of net energy needed. All feeds reported fed are included in the amount received. The amount needed includes adequate allowances for body maintenance of all cows in the herd plus the amount required for milk production at the average herd level. A feeding index of 100 indicates a balance between energy needed and energy provided. Several factors could cause this index to be either higher or lower. If it is above 100 it is possible that the amount or quality of the various feeds, especially forages, were estimated too high, that the herd may be gaining in average body weight, or that the test day performance may have been lower than normal. The amounts of feed actually eaten by the herd should be entered, not the amount fed, which includes a considerable amount of waste. A low feeding index would indicate the opposite of the above conditions. Since most cows enter the herd as 2-year-olds and leave as mature cows, energy for growth must be provided. In most herds, a feeding index within a range of 110-115 would indicate that sufficient additional energy was being provided to cover growth requirements.

Individual cow information. On each cow's line, under "test day data," the number of pounds of concentrates fed is recorded. In addition, there is a figure "pounds indicated." This is the amount required by each cow to provide energy for body maintenance and milk production. It takes into account the proportionate amount of forage each cow may have eaten in relation to her body weight as well as the amount received through concentrates. Its precision will depend largely upon how well the dairyman and the supervisor estimate the amount and quality of forages. The "pounds indicated" figure is not necessarily a recommendation on how much to feed, but it can be a useful guide. The amount of concentrates fed must take into account body condition, stage of lactation and other factors known only to the dairyman.

In addition to the test day data and the current month's production information on each cow, each cow's lactation-to-date information is carried each

month Each cows information will always be completely up to date in all details

Explanatory notes appear at the bottom of the sheet When an asterisk (*) appears in the days-carried-calf column it shows that a cow has carried a calf more than 220 days and should be turned dry in order to have a 60-day dry period before calving again When an asterisk appears in the days in milk column it shows that the cow has been fresh more than 60 days and no breeding date has yet been reported so either the cow should be bred in order to obtain a normal calving interval of 12 to 13 months or you should provide the *supervisor* with an up-to-date record of cows bred

Interpretation of special information included in the report (Figure 7 1)

1 Cows 9 and 26—Normal cows in milk, no change of status since the previous month
2 Cows 28 and 56—Breeding date shown (in "status" column)
3 Cow 42—Cow completing a 305-day record while still in milk (# in Condition Affecting Record [C A R] column the last column)
4 Cow 44—Cow terminating a lactation record of less than 305 days by being sold (# and □ in C A R column)
5 Cows 45, 52 53 and 54—(* in milk) Breeding reminder
6 Cow 46—(* in days carried calf) Drying-off reminder
7 Cow 46—Shows estimated record this month (1 in C A.R column)
8 Cow 48—Cow dry both last month and this month
9 Cow 49—Cow dry last month calved again old record terminated, new record started (□ in C A R column)
10 Cow 51—Cow abnormal mastitis (5 in C A R column)
11 Cow 54—Lame on test day foot rot (7 in C.A.R column)
12 Cow 57—Cow purchased while dry (negative income over feed cost)
13 Cow 58—Cow purchased while in milk, calving date or previous production not known
14 Cow 59—Temporary nurse cow too soon to test (9 in C A R column)
15 Cows 46 48 49 59—Eartags for grade cows
16 Cows 52, 53 54 56 59—First-calf heifers no days previous dry periods
17 Cows 28, 49, 52—Old barn name abbreviated to conform to 6-space central processing limit
18 Information on lines with no cow identification numbers barn names or index numbers provide additional data for the cow on the preceding line
19 Information for additional cows will be listed on succeeding sheets

Lifetime records for individual cows In addition to the monthly record provided by a testing program it is important to have complete information on each individual cow assembled where it can be summarized easily A record book containing forms similar to the one shown in Figure 7.2 is recommended for this purpose

Owner Sampler Records (OS)

This system of record keeping varies from the D H I.A. program in that the owner weighs and samples the milk himself and records all other pertinent data The same summaries and calculations are made for the owner as with the D.H I.A program Owner sampler records may be processed on electronic machines Records obtained in this manner are for the use of the herd owner or manager They are not approved by any agency are used to a limited extent in proving bulls

INDEX NO 0058

U. S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE

LIFETIME HISTORY OF INDIVIDUAL COW

BARN NAME: Kate	TATTOO NUMBER: —	EARTAG NUMBER: 25-BN-3794
REGISTRATION NAME: Fair Acres Admiral Fortune Kate		REGISTRATION NUMBER: 3387593
BREED: R.H. DATE OF BIRTH: 12/8/50	OFFICIAL TYPE CLASSIFICATION: GP (84)	CHECK IF COW IS PROGENY OF ARTIFICIAL INSEMINATION: ☑
SIRE: Meadow Glen Perfection Admiral		REGISTRATION NUMBER OF SIRE: 1013827
DAM: Fair Acres Cyclone Fortune	DHIA NUMBER: 0037	EARTAG OR REGISTRATION NUMBER OF DAM: 3046151

TEST DAY MILK WEIGHTS

LACT. NO.	DATE FRESH MO	DAY	YEAR	MONTH OF LACTATION 1	2	3	4	5	6	7	8	9	10	11	12
1	12	31	52	39.9	46.1	50.6	41.1	43.2	30.2	27.0	31.3	27.4	—	—	—
2	12	9	53	47.8	59.8	55.5	41.5	42.7	45.7	42.3	33.0	33.5	27.3	28.7	30.5
3	4	3	55	63.3	55.4	38.0	39.1	38.5	35.1	38.0	41.1	35.7	32.6	26.8	—
4	6	10	56	52.5	54.5	46.0	48.2	51.0	49.5	47.0	37.2	37.0	35.1	33.0	23.1
5	7	5	57	45.2	43.4	40.2	45.9	43.8	39.3	36.9	34.1	32.4	29.1	21.5	12.0
6	9	28	58	51.1	51.5	62.6	53.7	49.5	45.1						
7															
8															
9															
10															

LACTATION PRODUCTION SUMMARY

LACT. NO.	TYPE OF RECORD	AGE OF FRESHENING (Months)	WEIGHT WHEN FRESH	DAYS DRY BEFORE CALVING	FIRST 305 DAYS: DAYS CARRYING CALF	DAYS MILKED 3 TIMES	MILK	%	BUTTER FAT	COMPLETE LACTATION: DAYS IN MILK	LACTATION/LIFETIME TOTALS: MILK	B F	INCOME ABOVE F.C.	SUPVR'S INITIALS
1	DHIA	24	1100	—	218	—	10,880	3.8	409	296	10,880	409	251	DEY
2	DHIA	36	1200	57	103	—	11,240	3.8	436	419	14,700 / 25,580	555 / 964	347 / 598	DEY
3	DHIA	52	1300	61	154	—	14,640	3.7	542	369	15,670 / 41,250	597 / 1,561	417 / 1,015	DEY
4	DHIA	66	1400	65	187	—	13,910	3.7	520	362	15,620 / 56,870	587 / 2,148	398 / 1,413	DEY
5	DHIA	79	1500	38	146	—	11,750	3.6	423	363	12,860 / 69,730	458 / 2,606	319 / 1,732	DEY
6	DHIA	93	1500	87		—								
7														
8														
9														
10														

DHIA Form [illegible]
[illegible]

Figure 7.2. A record form, available for use with DHIA records processed on electronic machines, for summarizing the lifetime production, health, and reproductive performance of a cow.

BARN NAME Kate

INDEX NUMBER 0058

CALVING RECORD

LACT NO.	DATE OF CALVING MO.	DAY	YEAR	CALF'S NAME & EAR TAG NUMBER	SEX OF CALF	SIRE OF CALF	DISPOSAL OF CALF
1	12	21	52		M	H-35 (994378)	Vealed
2	12	9	53	25 WB 3468	F	H-39 (1137694)	
3	4	3	55	25 WB 3976	F	H-54 (1189647)	
4	6	10	56		M	H-54 (1189647)	Vealed
5	7	5	57	Jerry (1356487)	M	H-72 (1239632)	12/18/57 John Doe $3[illegible]
6	9	28	58	25 WAB 8955	F	H-72 (1239632)	
7							
8							
9							
10							

BREEDING RECORD

LACT NO.	DATE OF CALVING MO.	DAY	YEAR	DATE BRED	SIRE USED	DATE BRED	SIRE USED	DATE BRED	SIRE USED	DATE BRED	SIRE USED	REMARKS
1	12	21	52	3/18/53	H-39							
2	12	9	53	3/10/54	H-39	6/12/54	H-54	7/3/54	H-54			
3	4	3	55	9/3/55	H-54							
4	6	10	56	10/8/56	H-72							
5	7	5	57	10/5/57	H-72	12/29/57	H-72					
6	9	28	58	1/5/59	H-80	3/20/59	H-80					
7												
8												
9												

HEALTH AND VETERINARY RECORD MAINTAINED BY OWNER

DATE	DISEASE, AILMENT OR TEST	TREATMENT AND REMARKS	Cost
6-5-53	Bloated on alfalfa pasture	Dr Brown - used stomach pump	$8.00
11-2-55	Brucellosis Blood test	Dr Brown - Negative	$1.50
11-17-58	Ketosis	Dr Jones - glucose given	$10.00
2-21-59	Vaccinated for "Lepto"	Dr Jones	$2.00

U. S. GOVERNMENT PRINTING OFFICE

Figure 7.2

and cannot be published in the same manner as regular D.H.I.A. records.

Weigh-A-Day-A-Month (W.A.D.A.M.)

In this program, the owner weighs the milk from each cow one day each month, and enters the weight and feeding information on the forms provided. He mails the information and forms to the supervisor or a central office, where calculations are completed and summaries returned to the owner. Records made in this system are for the use of the herdsman or owner only.

BREED PROGRAMS

The registry associations all sponsor testing programs as an aid to improving the quality of their cattle and as a method of publicizing the breed. Details of these programs are published in a booklet entitled: "Unified Rules for Official Testing" available from each breed association or from the State Supervisor of Production Testing.

Herd Improvement Registry

All of the major breeds have a program of production testing of this kind.

Testing is conducted by a supervisor or tester employed by the State Superintendent of Production Testing. The supervisor visits the farm involved for two consecutive milkings (three milkings for herds on 3× milking), identifies all cows in the herd, weighs the milk from each cow, and takes a representative sample from each milking. The samples are combined for determination of the fat content of each cow's production. The supervisor records milk weight and fat tests on forms provided by the breed association and mails them to the association for processing. All registered cows, with few exceptions, must be included in the program, which is conducted on a yearly basis. Monthly and summary information is returned to the owner from each test.

Herd averages and production records of individual cows are certified and published by the breed associations. Production records are used in sire evaluation and in recognition programs of the associations involving outstanding animals and breeders.

Advanced Registry (A.R.)

This system is known by varying names in different breeds. It is not provided by the Ayrshire Association. It is designed to provide produc-

tion information on one or more individual registered cows in a herd

The State Superintendent of Official Testing is responsible for the supervisors or testers who visit farms in this program A test period of 24 to 48 hours with a preliminary dry milking is required each month. Daily milk weights must be kept and sent to the breed association monthly

Records are used in much the same manner as indicated for H I R. testing The A R program is the least used of those mentioned, and participation in it is declining

Dairy Herd Improvement Registry (D H I R.)

This most recent of recording programs is conducted co-operatively by the breed associations and the Cooperative Dairy Herd Improvement Program In this system, records recognized as official by both groups may be obtained in one program The general provisions are as follows

The herd must be already enrolled in regular D H I A, with the records processed by electronic equipment The owner makes application to the breed association for inclusion in the D H I R. Program Summaries of records processed at the D H I A computing center are supplied the registry association, which utilizes them in the same way as they do records from the regular breed programs

Cost of Record-Keeping

The cost of providing the records discussed above is borne by the herd owner There is some variation in charges, depending on the amount of service rendered Some area variations also occur The information provided by any of them is worth much more than the cost involved

Personal Records

The foregoing discussion has concerned record keeping systems sponsored by various agencies or organizations Personal record systems may be developed which are quite satisfactory Several groups interested in dairying have forms available for such records

Choosing a Record System

The decision of the individual dairyman as to what record system to adopt should be based upon the use he intends to make of the records No dairyman can afford to be without records of the amount and cost of items going into production These are provided by the D H.I A. and

the Owner-Sampler programs. A dairyman selling cattle for production purposes can benefit by having official records provided by the breed programs or D.H.I.A.

Anyone deeply interested in purebred cattle will find that official breed records provided by H.I.R., A.R., or D.H.I.R. increase the market value of his cattle and make it possible for him to enjoy the benefits of the breed-recognition programs. The D.H.I.R. program answers all of the above criteria and appears to be one which will enjoy the most widespread participation.

FURTHER READING

Unified Rules for Official Testing, Peterborough, New Hampshire: The Purebred Dairy Cattle Association, revised 1959.

Kendrick, J. F., *The DHIA Supervisor's Manual,* U.S D.A. Agricultural Handbook 96, Washington, D.C.: U.S. Government Printing Office, revised 1957.

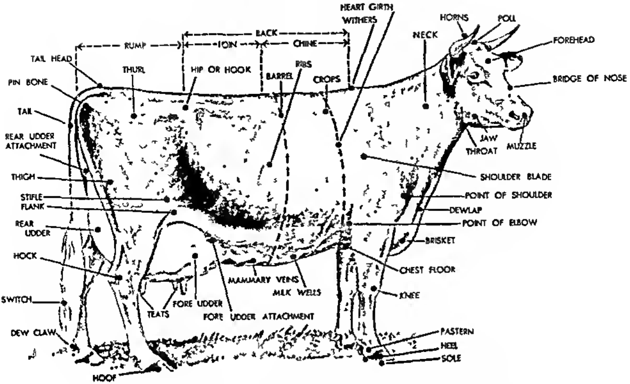


Figure 8.7. The parts of the dairy cow. Courtesy the Purebred Dairy Cattle Association.

dairy character, as described in Figure 8.6, appear to be more closely related to production than other characteristics are. The correlation between production and dairy character is reported as between .14 and .24.

It is generally accepted by dairy-cattle geneticists that the characteristics for high production and the factors which establish body conformation are inherited separately to a large degree. For high correlations to exist between any two characteristics, they must be inherited in close association.

The claim is sometimes made that cattle of good type have a longer productive life and reach higher production levels than those of poor type. This question is difficult to evaluate, since the type classification of an animal may itself be a more important factor in culling or disposal than failure of the animal to function properly. It may also affect the feeding and management conditions to which she is subjected within a herd. There is no doubt that such a fault as weak udder attachments leading to a pendulous udder does restrict the usefulness of a cow.

METHODS OF EVALUATING TYPE

Breed Classification Programs

Each of the dairy breed associations employs trained men to classify or provide type evaluation on cattle registered with the association. This

8 Evaluating Type in Dairy Cattle

"TYPE" in dairy cattle is usually understood to mean the appearance and body conformation of an individual as compared to a standard of excellence. Since the earliest domestication of cattle, men have striven to develop animals which excelled in appearance and conformation. Developing individuals and families which closely resemble the ideal established for the species or breed has been a source of satisfaction and pride to animal husbandmen wherever they have existed.

Today, in addition to adherence to a specific standard, desirable type is understood by most dairymen to refer to the kind of cow which is adapted to the pattern of modern herd management. Emphasis is placed on profitableness and meeting the reasonable needs of dairy farmers.

ESTABLISHMENT OF TYPE STANDARDS

A quotation is given in Chapter 1 of a type standard for dairy cattle in ancient Rome. Ideals of type have existed, in many forms and variations, in local areas since the beginning of animal husbandry. The standards for type in dairy cattle presently in use originated with the founding of purebred organizations in the last half of the nineteenth century. Type-classification programs were started in this country in 1929. Type standards for dairy cattle are dynamic and subject to change. As new ideas or information develop, they are incorporated into the standards.

Current Type Standards for Dairy Cattle

Each of the major dairy-breed associations has an active committee on dairy-cattle type. These meet regularly and review and modify the type characteristics considered ideal for the breed. The standard established by this committee then becomes a "trademark" for the breed.

Figures 8.1, 8.2, 8.3, 8.4, and 8.5 depict the "true type" cows of the five major dairy breeds.

Type standards for the major breeds are remarkably similar, with

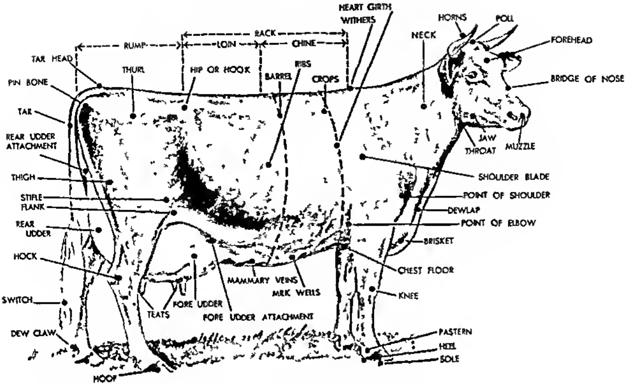


Figure 8 7. The parts of the dairy cow Courtesy the Purebred Dairy Cattle Association.

dairy character, as described in Figure 8 6, appear to be more closely related to production than other characteristics are. The correlation between production and dairy character is reported as between .14 and .24.

It is generally accepted by dairy-cattle geneticists that the characteristics for high production and the factors which establish body conformation are inherited separately to a large degree. For high correlations to exist between any two characteristics, they must be inherited in close association.

The claim is sometimes made that cattle of good type have a longer productive life and reach higher production levels than those of poor type. This question is difficult to evaluate, since the type classification of an animal may itself be a more important factor in culling or disposal than failure of the animal to function properly. It may also affect the feeding and management conditions to which she is subjected within a herd. There is no doubt that such a fault as weak udder attachments leading to a pendulous udder does restrict the usefulness of a cow.

METHODS OF EVALUATING TYPE

Breed Classification Programs

Each of the dairy breed associations employs trained men to classify or provide type evaluation on cattle registered with the association. This

service is available to persons owning registered cattle upon application and payment of fees.

Detailed information is given to the owner on the desirable and undesirable characteristics of the parts of each animal classified. This enables the breeder to determine where he may wish to improve or change the body conformation in replacements chosen for the herd. It provides him with an estimate of how animals in his herd compare with the breed standard and with the average of other animals in the breed.

Classifiers take into account the age, condition, and any injuries of the animal. An attempt is made to evaluate the strong points or weakness of cows as separated from the effects of environment. Having the classification done by a professional person provides an unbiased opinion It also places the classifier in the position of comparing the animals in a given herd with those representing a large portion of the breed.

Different terms are used by some of the breed associations to designate animals falling in various scoring ranges These terms and the scoring ranges they cover are included in Figure 8.8. More complete details about individual programs are available from each of the breed associations.

	BREEDS				
Scoring Range	*Ayrshire*	Brown Swiss	Guernsey	*Jersey*	*Holstein*
90+	Excellent	*Excellent*	*Excellent*	Excellent	Excellent
85–89 9	Very good	Very good	*Very good*	Very good	Very good
80–84 9	Good Plus	Good Plus	Desirable	*Good Plus*	*Good Plus*
75–79 9	Good	Good	Acceptable	Good	Good
70–74 9	Fair	Fair	Fair	Fair	Fair
65–69	Fair	Fair	Poor	Fair	Fair
–65	Fair	Poor	Poor	Fair	Poor

Figure 8 8 *Summary of Terms Used in Herd-Classification Programs by the Five Major Dairy Breeds In addition to the terms included here, some of the Breed Associations report numerical scores on classified animals*

The Show Ring As a Type Standard

There are innumerable fairs and field-days each year in which cattle are shown in competition to determine the best body conformation in each age group. These shows range from local county coverage to the large national and international shows held annually.

In the show ring, the animals are evaluated by a competent judge and ranked according to over-all merit. Numerical scores are not given,

but the evaluation is made in accordance with the system shown in Figure 8.6. Figure 8.9 is a picture of the placing of a class of cattle at a National Show.

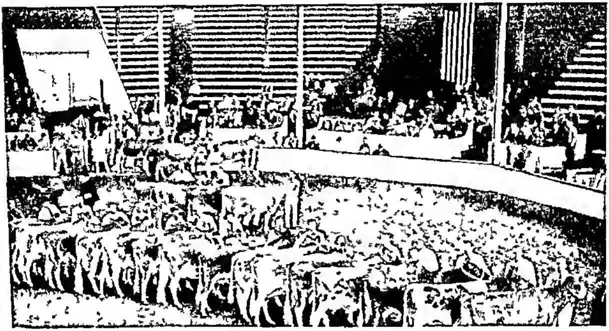


Figure 8.9. An outstanding class of 3-year-old Guernsey cows, presented at a national show. Courtesy The American Guernsey Cattle Club

No allowance is made for injuries, disease, or condition. The animals are placed as they appear in the ring. Frequently animals place in different ranks in succeeding shows as their condition or appearance changes. Considerable skill is associated with preparing an animal for the show ring and leading her in the show. Giving the details of this art would take too long for this text. However, each of the breed associations provides excellent material on the fitting and showing of cattle.

Probably the greatest contribution of the show ring to the dairy cattle industry is the interest and enthusiasm which it creates. In addition to the competitive desire among the participants to show the best animals, shows give other breeders an opportunity to observe the standards established for good cattle. Presentation of cattle where they are observed by the general public is helpful in explaining the dairy industry for their benefit.

The following list is of specific defects which are considered in the show ring. These are taken from the Dairy Cow Unified Score Card, by courtesy of the Purebred Dairy Cattle Association. (In a show ring, disqualification means that the animal is not eligible to win a prize. Any disqualified animal is not eligible to be shown in the group classes. In slight to serious discrimination, the degree of seriousness is determined by the judge.)

EYES

1 Total blindness *Disqualification*
2 Blindness in one eye *Slight discrimination*
3 Cross-eyes *Slight discrimination*

WRY FACE

Slight to serious discrimination

CROPPED EARS

Slight discrimination

PARROT JAW

Slight to serious discrimination

SHOULDERS

Winged *Slight to serious discrimination*

TAIL SETTING

Wry tail or other abnormal tail settings *Slight to serious discrimination*

LEGS AND FEET

1 Lameness—apparently permanent and interfering with normal function *Disqualification*
—apparently temporary and not affecting normal function *Slight discrimination*
2 Bucked knees *Slight to serious discrimination*
3 Evidence of arthritis crampy hind leg *Serious discrimination*
4 Boggy hocks *Slight to serious discrimination*

ABSENCE OF HORNS

No discrimination

LACK OF SIZE

Slight to serious discrimination

UDDER

1 Blind quarter *Disqualification*
2 Abnormal milk (bloody clotted watery) *Possible disqualification*
3 Udder definitely broken away in attachment *Serious discrimination*
4 A weak udder attachment *Slight to serious discrimination*
5 One or more light quarters hard spots in udder obstruction in teat (spider) *Slight to serious discrimination*
6 Side leak *Slight discrimination*

DRY COWS

Among cows of apparently equal merit *Give strong preference to cows in milk*

FREEMARTIN HEIFERS

Disqualification unless proved pregnant

OVERCONDITIONED

Slight to serious discrimination

TEMPORARY OR MINOR INJURIES

Blemishes or injuries of a temporary character not affecting animal's usefulness *Slight discrimination*

DAIRY TYPE APPRAISAL RECORD*

Prepared by Extension Division, Animal Husbandry Department, Cornell University

E T Reg ________ Born Name ________ Reg. Sire ________ E T Dam Reg ________

Age Yr. ____ Mo ____ Breed ________ Last Date Fresh ________ Owner ________ County ________ Date ________

Dairyman Checks Items within the Solid Line

TEMPERAMENT

Quiet	1
Nervous	2
Dull, Stolid	3

FEEDING HABITS

Aggressive Feeder	1
Average Feeder	2
Slow Feeder	3

INCIDENCE OF MASTITIS

No Mastitis	1
Mastitis 1st lactation	2
Mastitis - Injury	3
Mastitis - Other causes	4

KETOSIS - MILK FEVER

No Ketosis - Milk Fever	1
Afflicted Ketosis	2
Afflicted Milk Fever	3
Afflicted - Both	4

BREEDING TROUBLE
(4 or more services)

No breeding trouble	1
Cystic Ovaries	2
Other breeding troubles	3

MILKING QUALITIES

Milks fast less than 4 min	1
Milks in 4-6 min	2
Milks slow 6 min	3

MILK LEAK

Non leaker	1
Leaks Milk	2

UDDER EDEMA (Caked) AFTER CALVING

None to slight	1
Moderate	2
Severe	3

TAPED WEIGHT ________ lbs.

DAIRY CHARACTER
(Consider stage of lactation)

Sharp, Angular	1
Moderate	2
Coarse or Thick	3

HEAD

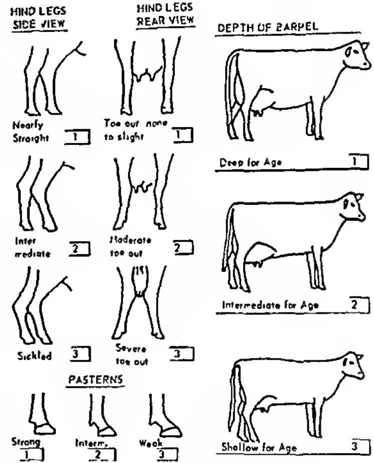
Typical for breed	1
Plain	2
Coarse or Beefy	3

SHOULDER

Not winged, tight	1
Slightly winged loose	2
Severely winged	3

BACK (Hip to Shoulder)

Straight	1
High Chine	2
Low Loin	3
Low Chine	4
Roached	5
Sway Back	6



*Reproduction of this form in whole or part permitted if source is credited.

Figure 8.10. Dairy type appraisal record, prepared by the Extension Division, Animal Husbandry Department, Cornell University, Ithaca, New York.

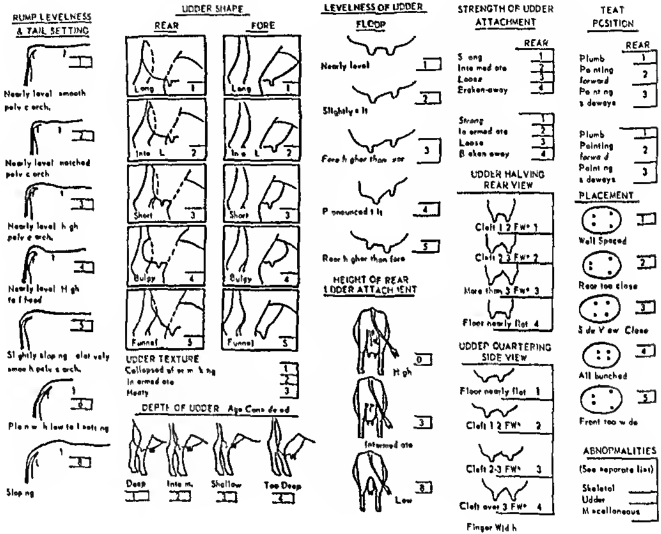

RUMP LEVELNESS
& TAIL SETTING
Nearly level smooth
Nearly level notched
Nearly level high
Nearly level High
Sloping
UDDER SHAPE
REAR
FORE
Long
Short
Bulgy
Funnel
UDDER TEXTURE
Meaty
DEPTH OF UDDER
Deep
Shallow
Too Deep
LEVELNESS OF UDDER
FLOOR
Nearly level
Rear higher than fore
HEIGHT OF REAR
High
Low
STRENGTH OF UDDER
ATTACHMENT
REAR
Loose
Broken-away
Strong
UDDER HALVING
REAR VIEW
Floor nearly flat 4
UDDER QUARTERING
SIDE VIEW
Floor nearly flat 1
Cleft 2-3 FW 3
Finger Width
TEAT
POSITION
REAR
Plumb
Pointing
Pointing
PLACEMENT
Well Spaced
Rear too close
All bunched
ABNORMALITIES
(See separate list)
Skeletal
Udder

Figure B 10

EVIDENCE OF SHARP PRACTICE

1. Animals showing signs of having been operated upon or tampered with for the purpose of concealing faults in conformation, or with intent to deceive relative to the animal's soundness: *Disqualification.*
2. Uncalved heifers showing evidence of having been milked: *Serious discrimination.*

Type Appraisal by Herd Managers

The two systems of type appraisal just discussed are available only to owners of purebred cattle who participate in the programs outlined. There may be numerous instances in other herds where evaluation of type is desirable. Anyone may use the P.D.C.A. chart, shown in Figure 8.6. A type-evaluation chart which provides more detail about individual parts of the animal is presented in Figure 8.10. This chart is particularly useful for the person learning to appraise type in his herd. If each animal is scored and a summary developed for the herd, it can be useful in evaluating strong and weak points in the herd, or in sire groups, as well as in selecting individuals. In addition to physical structure, the chart contains physiological characteristics which are helpful in arriving at the comparative value of cattle in a herd.

LEARNING TYPE APPRAISAL

The successful herdsman must be able to recognize and evaluate serious body defects in cattle for good herd management. If the herd is *to participate actively in purebred programs, or to serve as a source of* purebred stock, he must be thoroughly familiar with the type appraisal. Continual practice is the only way to accomplish this.

Participation in formal courses and breed-sponsored judging schools and familiarity with available literature on the desirable type characteristics of the breed of interest are helpful. Observation of shows and classification programs is desirable. Several references to literature on type appraisal of dairy cattle are given below.

FURTHER READING

Purebred Dairy Cattle Association, *Showing and Judging Procedures for Dairy Cattle.* Peterborough, New Hampshire: The Purebred Dairy Cattle Association.

Trimberger, G. W., *Dairy Cattle Judging Techniques,* Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1958.

Yapp, W. W., *Dairy Cattle Judging and Selection,* New York: John Wiley and Sons, 1959.

9 Selecting and Breeding Dairy Cattle for Profit

THE objective of dairy cattle breeders is to mate individuals whose offspring will be as close as possible to the ideal, in amount and characteristics of milk production and in body type. The degree of emphasis on each of these three items depends upon the market available and the desires of the breeder. In many instances, more specific factors, which, it is hoped, contribute ultimately to the above goals, may be the ones actually chosen. Selection of animals for breeding on the basis of the information usually available is a difficult task. Not only is information limited, but the proper interpretation of it requires much effort and a broad background of technical knowledge.

Always select the best animals possible when choosing animals for breeding. Selection of good males is extremely important because of their widespread use. An individual cow will have only a few offspring in a herd, while a bull may be responsible for all the replacements for a considerable period. Dairymen who use a bull which transmits undesirable characteristics not only risk their own future business, but they slow the progress of the entire dairy production industry.

BASIS OF INHERITANCE

The entire potential for each new individual is equally divided between the male and female reproductive cells which unite to form this individual. This is true not only for what the new individual will be, but also for the characteristics it can pass on to its offspring in turn.

Structure of Reproductive Cells

All cells have a general structure similar to that shown in Figure 9.1. The nucleus of reproductive cells contains the structures which control inheritance.

The nucleus of all cells contains structures called *chromosomes*. These are minute and threadlike in form. Associated with each chromosome are many units called *genes*. The genes are chemical units of inheritance,

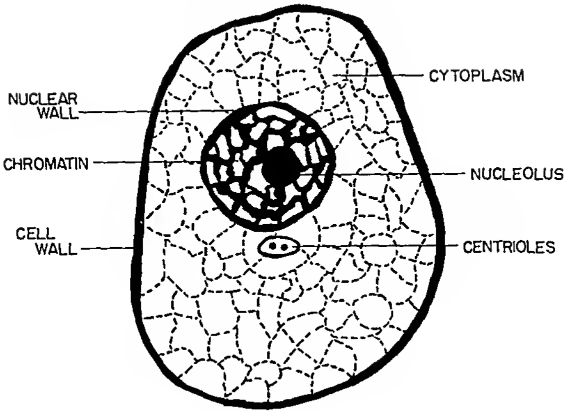


Figure 9.1. Diagram showing the major components of an animal cell.

responsible for all of the heritable characteristics of animals and plants. The exact method by which genes control the characteristics of new individuals is not known. However, research has uncovered considerable information about the mathematical possibility for the occurrence of *many characteristics. The number of genes affecting a given characteristic*, and facts about the interaction of them, are known for some characteristics.

Chromosomes exist in normal body cells in pairs. Each member of a pair of chromosomes carries genes for the same characteristics as its mate. Each gene is found at approximately the same location on its chromosome as its corresponding gene, or *allele*, on the other member of the chromosome pair. Thus, each cell contains a great many pairs of genes which account for all the inherited characteristics of the animal.

In dairy cattle there are 30 pairs of chromosomes in each cell, with unknown numbers of genes. The individual members of a pair of genes may be directed to the same, or widely different, manifestations of the characteristic to which they apply. For example, one gene may be for black color in cattle and its mate for red. There are all degrees of relationship between different paired genes in exerting their influence on the appearance of an animal. One gene may be completely dominant over the other, so that only two conditions are possible in the live animal, or there may be intermediate expressions of the genes between the two extremes.

Genes are transferred to new individuals and manifested according to Mendelian principles, or Mendel's Laws These are named for Gregor Johann Mendel, an Austrian monk, who was a student of heredity and established these principles in the late nineteenth century

Cell division When body tissues grow by cell division, the chromosomes and accompanying genes duplicate themselves, and each new cell is a replica of the parent cell This type of cell division is called *mitosis* It is demonstrated in a simplified diagram in Figure 9 2

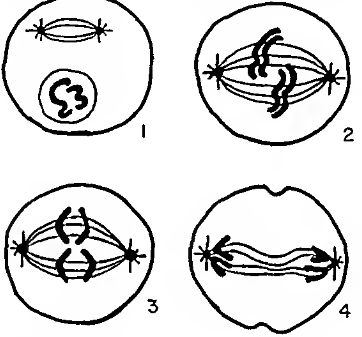


Figure 9 2 Diagram outlining the duplication of chromosomes in cell division during growth Two chromosomes are shown In 1, the chromosomes become visible as slender threads In 2, the chromosomes have duplicated themselves The thread-like structures are called the spindle The organized structures on each side are the centrioles In 3, the duplicated chromosomes have started to separate In 4 the chromosomes have moved to the area of the nuclei of the two new cells The beginning of the division of the cell membrane is indicated This division continues until there are two separate cells

A specialized type of cell division takes place in the formation of reproductive cells (sperm and egg cells) in the testes and ovary This is called *meiosis* At a given stage of development, two cell divisions take place in fairly rapid succession In one of these the chromosomes do not duplicate themselves, thus, the resulting cells have only one-half the usual number of chromosomes, with one member of each pair being represented The combinations of chromosomes occurring in each reproductive cell are a random sample of those present in the original cell

There is frequently intertwining of chromosomes, with some breaking off and rejoining of material at the time of division, which adds to the number of possible new genetic combinations.

A simple diagram indicating the process of meiosis is presented in Figure 9.3.

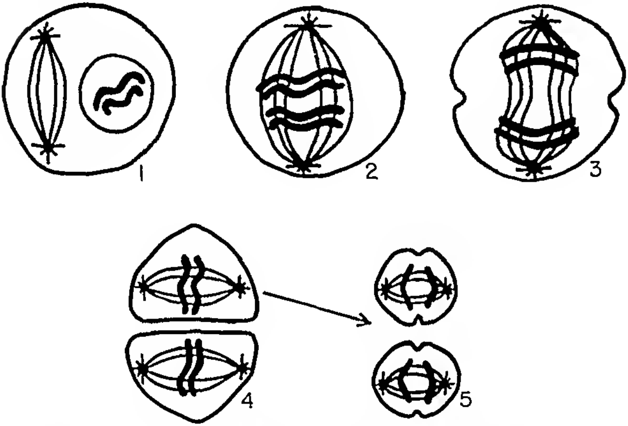


Figure 9.3 Diagram outlining cell division giving one-half the normal number of chromosomes, as occurs in the production of eggs and sperm In 1, 2 and 3, cell division similar to that shown in Figure 9.2 is indicated. In 4 and 5 a cell division is shown in which there is no duplication of chromosomes, resulting in one-half the usual chromosome number.

At the time of fertilization, the nuclei of the egg and sperm, each with one-half the usual chromosomes, join, and the normal chromosome number is re-established in the *zygote*, the cell that develops into the new individual.

This procedure provides for 50 per cent of the offspring's inherited traits coming from each parent. In addition, it accounts for the appearance of different phenotypes (the different kinds of appearance or performance of an animal) in offspring than are seen in either parent. The conditions of dominance and recessiveness, and the many interactions existing between genes, rarely result in the same milk production or other characteristics in the progeny as are shown by the parents. This also accounts for the considerable variation between full brothers and

sisters, since huge numbers of chromosome and gene combinations are possible where 30 pairs of chromosomes are involved

(*Dominance* and *recessiveness* refer to a condition in which the phenotype of the animal shows the characteristics of one gene, the dominant one, to the exclusion of the characteristics of its allele, the recessive gene *Interaction* is a term used to indicate situations in which the phenotypic expression of a characteristic may be the result of many genes acting in different ways to influence the given characteristic)

Examples of Gene Interaction in Heredity

Although the appearance and producing ability of cattle are a result of their gene combinations, there is much masking of one gene by its mate, or interaction between different genes This makes the determination of genes actually present in an individual (its genotype) by observation of its external appearance or abilities (its phenotype) difficult and, in many instances, impossible

Examples of two methods of interaction of genes are given in Figure 9 4 The color characteristic, shown in the first example, acts througb complete dominance and recessiveness Cows having genes BB or Bb are black, those having the gene combination bb are red. (Capital letters indicate dominant characteristics, lower-case letters, recessive ones) Individuals having both members of a pair of genes the same (BB or bb) are *homozygous* for the characteristic, those with mixed genes (as Bb) are called *heterozygous* It can be readily seen that it is impossible to identify animals with the genotype Bb or BB from appearances alone The only way identification of the genotype of a single animal can be made is by observing sufficient numbers of offspring from matings with animals having the genotype bb

The second example presents the possible combinations when partial dominance exists The example is the inheritance of color in Shorthorns In this case, the genotype is readily discernible from observing the phenotype

In addition to the examples given, there are many more complicated instances of interaction of genes, including those which involve more than one pair of genes The capacity for milk production, and many other economically important characteristics of dairy cattle, are controlled by many genes The level of several hormones, the amount of secretory tissue, the ability to consume and digest feed, and a number of other factors are undoubtedly involved in determining milk producing ability

Mathematical analysis of production records and comparison of progeny with ancestors indicate that milk production is mainly inherited on an additive basis That is, the producing ability of a given individual is the sum of a number of factors inherited from each parent

Example I
Simple Dominance and Recessiveness in Heredity as Shown by the Control of Color in Holstein-Friesian Cattle. (The degree of spotting or white coloring is controlled by other factors.)

	PARENT X	PARENT Y
Phenotype	Black	Black
Genotype	Heterozygous Bb	Heterozygous Bb

POSSIBLE OFFSPRING

Genotype	1.[a] BB Homozygous	2[a] Bb Heterozygous	1.[a] bb Homozygous
Phenotype	black	black	red

Example II

Interaction of Genes (Partial Dominance) in Heredity as Shown by the Control of Color in Shorthorn Cattle.

	PARENT A	PARENT B
Phenotype	Roan	Roan
Genotype	Heterozygous Rr	Heterozygous Rr

POSSIBLE OFFSPRING

Genotype	1.[a] RR Homozygous	2.[a] Rr Heterozygous	1.[a] rr Homozygous
Phenotype	red	roan	white

[a] Numbers refer to the ratio in which these combinations are expected to occur.

Figure 9.4 A Simple Demonstration of Two Types of Interaction Between Genes.

A sample model system is presented in Figure 9.5. A little experimenting with other possible combinations making up an offspring from the parents shown in Figure 9.5 will help explain the great variation in production frequently observed in closely related animals.

Inheritance of Economically Important Characteristics

The successful animal breeder must have an understanding of the degree to which characteristics which he wishes to improve are heritable, and of the rate of progress he can reasonably expect to achieve. He also must use the best methods available to evaluate the animals under

GENOTYPE OF THE PARENTS

Sire				Dam			
Genes	Total milk prod. (lbs)	Genes	Total milk prod (lbs)	Genes	Total milk prod (lbs)	Genes	Total milk prod (lbs)
A	500	a	700	a	700	A	500
B	1000	B	1000	b	600	b	600
C	1500	c	3500	c	3500	c	3500
D	800	d	3700	d	3700	D	800
E	600	E	600	e	550	E	600
F	600	f	1200	f	1200	F	600
G	100	g	350	g	350	g	350
Sire s total potential production 16 150 lb				Dam s total potential production 17,550 lb			

GENOTYPES OF TWO OFFSPRING

Inheriting the Highest Possible and the Lowest Possible Producing Ability from these Parents

Genes	Total milk prod. (lbs)	Genes	Total milk prod (lbs)	Genes	Total milk prod. (lbs)	Genes	Total milk prod. (lbs)
a	700	a	700	A	500	A	500
B	1000	b	600	B	1000	b	600
c	3500	c	3500	C	1500	c	3500
d	3700	d	3700	D	800	D	800
E	600	E	600	E	600	e	550
f	1200	f	1200	F	600	F	600
g	350	g	350	G	100	g	350
Highest potential production 21 700 lb				Lowest potential production 12 000 lb			

Figure 9.5 A model showing how m lk product on might be inherited on an add tive bas s. The letters represent inher ted factors that influence m lk product on (There are of course more than seven factors involved although the exact number is unknown.)

consideration In evaluating animals for breeding purposes the under standing of a few terms is necessary

Repeatability (r) This is the portion of superiority or inferiority of a given record on an individual as compared with the herd average, which may be expected in future performance of that individual Repeatability for milk and fat production in dairy cattle is about 40 For fat per cent it is between .50 and 60 For example a cow produces 550 pounds of fat in a herd with an average production of 500 pounds On the average 50 × 4 or 20 pounds difference from the 500-pound herd average, may be expected in future lactations by this cow in the same herd

Heritability (h) This is the portion of superiority or inferiority, above

or below the herd average, that an animal transmits to its offspring. Heritability for milk and fat production in dairy cattle has been found to average about .25. For fat test, h is about .50. There is some variation in this figure depending on the degree to which environmental influences can be accurately estimated. For example: a cow in a herd with an average production of 13,000 pounds of milk has an average production of 15,000 pounds. 2,000 × .25 or 500 pounds of this difference can, on the average, be credited to inheritance, and 1,500 pounds to favorable environment. Similar adjustment should apply to animals producing less than the herd average.

The above factors can be useful in making more realistic appraisals of the actual producing ability of cows.

Production of milk and butterfat. The capacity for milk production, and the composition of milk produced, are inherited characteristics. Definite changes have been brought about by selecting animals for certain production characteristics. Families or strains have been developed within breeds which exhibit characteristic butterfat percentages in their milk. Because heritability of these characteristics is not extremely high, progress in improving the producing ability of cows by selection and breeding is not very rapid.

Recently, there has been increased interest in the inheritance of the solids-not-fat content of milk. Less is known about this than about the heritability of butterfat or total milk production. A large co-operative research project is under way to establish more complete information about solids-not-fat and the degree to which it is inherited. With changing demands by the public for food, it may become increasingly important to provide milk of a high solids-not-fat content. Selection for this quality may be practiced in the future.

Inheritance of Type Characteristics

The characteristics making up good dairy type are influenced to a slightly higher degree by heredity than are those for milk production. The coefficient of heritability here is usually found to be about .30. There is, of course, some variation about this figure in studies involving different populations of cows. However, it appears that progress in improving type can be as rapid as or slightly more rapid than for production.

The repeatability of type score on the same animal is about the same or a little lower than that for milk production. This is due to variations between men classifying the animal and to the changes which take place as the animal becomes older. A major portion of variation is brought about when females are classified before and after development of the udder. This is logical when we consider that the udder makes up 30

per cent of the type score in mature cows and none of it in younger animals.

Inheritance of feed efficiency and consumption. The degree of efficiency with which the individual animal converts feed into milk is extremely important. This is an area which has not been adequately studied, and more information is needed. Current studies indicate that there may be differences between families of dairy cattle in feed efficiency.

A major factor in feed efficiency of dairy cows in regard to milk production is the amount of feed eaten. As the cow consumes more feed, the percentage of nutrients available for production, after the needs for maintenance are met, increases rapidly. The ability to consume large amounts of feed is essential for high production. Many hereditary factors other than feed efficiency and consumption are limiting to milk production. However, it may well be that, as more information becomes available, this factor will be added to the list for consideration in selecting dairy cattle. Feed efficiency and production level are highly correlated ($r = .71$ to $.75$).

Fertility. Present information indicates that only limited improvement in fertility may be made by selecting specifically for it. There is considerable self-selection against infertility in nature. Animals of low fertility leave substantially fewer offspring than those of high fertility. With the heavy demands of other items, where more progress can be made, the average breeder can gain little by including fertility in his list of items for selection. Of course, animals which have such a low rate of fertility that they are uneconomical producers should be eliminated.

Undesirable characteristics. There are numerous undesirable characteristics occurring in cattle which should be selected against. All of the lethal factors are included here. Fortunately, many of these are inherited as simple recessives, and animals carrying them can be identified over a period of time when accurate records are kept. Bulldog calves, various skin deficiencies, dwarfism, and other malformations can be easily identified. The factor for red color in Holstein-Friesian cattle is undesirable in purebred herds, since red calves cannot be registered. Sires known to be carriers of the lethal factors should be used only after careful evaluation of their contribution to breeding progress and of the cows to which they are to be bred. Calves from cows known to be carriers should not be raised, although the cows themselves may be satisfactory for production purposes. If there is a question about a sire, and if he is valuable enough otherwise to warrant it, breeding tests may be made to discover whether he carries a lethal recessive. Some of this is being done to detect dwarfism in beef cattle. The procedure is to mate the sire to a sufficient number of females known to be carriers of the lethal factor in question. If the factor does not show in any calves, the

sire may, with reasonable safety, be considered not to carry it. A minimum of 8 calves should be obtained in this type of test, and more are desirable.

Disease resistance. Little is known about heredity concerning resistance or susceptibility to disease. Limited information indicates that resistance to such diseases as mastitis and udder edema is inherited. This area is open to new findings and may also become a factor in selection in the future.

Longevity. Longevity is frequently mentioned as a factor in selection. Because cows are culled for so many economic factors, few have an opportunity to express their capacity for length of life. Disease resistance, fertility, and a number of other factors all affect the length of time that a cow remains in a herd. At present not enough cows are allowed to live to older ages to make it an important factor in selection. When a cow does have a long productive life with many good-quality offspring, there is a natural tendency to select toward the animal because of the number of progeny involved.

SOURCES OF INFORMATION AVAILABLE IN SELECTING BREEDING STOCK

Information from three major sources may be used in making evaluations of breeding stock. These sources are the progeny of the animal, the animal itself, and the ancestors or close relatives of the animal. Whatever source of information is used, a knowledge of the environmental condition concerned is highly important.

Progeny

The most desirable sources of information on the breeding potential of an animal are large numbers of its progeny. These provide actual examples of the genetic material passed on by the individual in question. With dairy cattle, the obtaining of production information on significant numbers of the offspring of a female is difficult, and usually impossible, during her reproductive life. The average cow has only one or two female offspring, and they do not complete a lactation until nearly 3 years after they are born. It is much easier to obtain information on the progeny of bulls. Information on the daughters of bulls used in natural breeding is frequently limited, although the use of a bull in tested and classified herds may provide the desired information. Artificial insemination provides an opportunity to obtain information on bulls, but even with full use of this tool, a bull will be at least 5 years old before sufficient numbers of his daughters have completed a lactation.

Production information on the progeny of bulls. Each of the breed

associations makes available production information on the daughters of registered bulls which are included in one of their testing programs The United States Department of Agriculture, through the Cooperative Dairy Herd Improvement Program, periodically calculates "bull proofs" on all bulls for which adequate information is available through its testing program For a number of years these provided a comparison of the production of a bull's daughters with that of their dams More recently the U S D A proofs have been expanded to include comparisons with other animals in the same herds calving at approximately the same time A sample copy of the bull proof form issued by U S D.A. is shown in Figure 9 6 Below is an explanation of the proved sire record shown in Figure 9 6, taken from material published by the Herd Improvement Section, Dairy Cattle Research Branch, Agricultural Research Service of the U S D A The points brought out here are useful in evaluating production information from any source

A DHIA proved sire record contains all usable records reported for his daughters and their dams, excluding only those records containing conflicting data The record of each dam or daughter consists of her production for the first 305 days of a lactation, standardized to a mature equivalent, twice a-day milking basis, or, when production records for more than one lactation are available for a dam or daughter, her record is based on the average of all usable standardized 305-day lactation records Incomplete and abortion records less than 305 days in length are extended to a 305-day basis and standardized and used only if a complete record is not available

At the top of the proved sire record is the identification number of the sire, together with his name, birthdate, and the identification of his sire and dam When a sire is proved for the first time, only the sire number is available at the time the proved sire record is compiled The additional pedigree data are then obtained from the respective breed organizations and this information included in the yearly index

In the body of the proved sire record are summaries of data included in the proof These data are compiled to show non AB comparisons, AB comparisons, and a combination of both non AB and AB data ("AB" *refers to* artificial breeding) A "preliminary" non AB proof consists of 5 to 9 comparisons A non AB proof consists of 10 or more comparisons A "preliminary" AB proof consists of 10 to 24 comparisons An AB proof consists of 25 or more comparisons

Preliminary proofs should be considered only as an indication and not conclusive evidence of the breeding value of a sire If the difference between butterfat production of dams and daughters is less than 25 pounds, additional dam and daughter comparisons may conceivably reverse the summary In general, the greater the number of dam and-daughter comparisons included in a proof, the more reliable the evidence of the sire's breeding value

However, if a non AB proof contains 17 or more unselected comparisons and an AB proof contains 50 or more unselected comparisons, additional data will seldom significantly affect the summary

Breeding Value Can Be Appraised—A proved-sire record provides the basic information to appraise a sire's breeding value Such a record on a herd sire will help the herd owner decide whether the sire should be used in his herd and will aid an AB sire selection committee in determining if the sire should be used in the area serviced by the AB stud

If a sire's daughters materially excel their dams and/or their contemporaries in production, the sire should continue to be used in herds having a produc-

DHIA PROVED SIRE RECORD FOR BREED HOLSTEIN

U S DEPT OF AGRICULTURE AGRICULTURAL RESEARCH SERVICE
DAIRY CATTLE RESEARCH BRANCH DAIRY HERD IMPROVEMENT SECTION

RECORDS FROM STATES 32-015 33-010 35-005

SIRE NUMBER 999999 NAME SAMPLE PROVED SIRE RECORD

BORN 6-15-49 SIRE 888888 DAM 777777

AB SERVICE 35-05 TABULATED 12-15-57 PREVIOUS TABULATION

SUMMARY	IDENTIFICATION NUMBER	AB		TYPE	DATE OF BIRTH	DAYS IN MILK NUMBER	RECORDS AVERAGED NUMBER	MILK AVERAGE POUNDS	FAT PERCENT	FAT AVERAGE POUNDS		FEEDING INDEX	305 DAY CONTEMPORARY HERD AVERAGE: RECORDS NUMBER	MILK POUNDS	FAT POUNDS	YEARLY HERD AVERAGE: RECORDS NUMBER	MILK POUNDS	FAT POUNDS
14 NON-AB DAU	------	-	-	85	--------	--	25	13902	3.8	522		97	25	13667	492	39	13889	500
13 NON-AB DAU	------	-	-	85	--------	--	23	13864	3.8	527		96	25	13667	492	40	13861	499
13 DAMS	------	-	-	84	--------	--	36	13765	3.8	522		95	DIFF.	ALL	DAU	& HERD	DATA	
DIFF 12-08-12	------	-	-	1	--------	--		99	.0	5		1		235	30		13	22
18 AB DAU	------	-	-	85	--------	--	23	14025	3.6	509		98	24	14056	506	38	14306	515
17 AB DAU	------	-	-	85	--------	--	21	14033	3.6	510		99	24	14056	506	41	14333	516
17 DAMS	------	-	-	83	--------	--	31	13288	3.7	487		97	DIFF.	ALL	DAU	& HERD	DATA	
DIFF 11-10-12	------	-	-	2	--------	--		745	.1-	23		2		31-	3		281-	6-
32 ALL DAU	------	-	-	85	--------	--	48	13964	3.7	516		98	25	13861	499	37	14167	510
30 ALL DAU	------	-	-	85	--------	--	44	13960	3.7	517		97	24	13889	500	40	14278	514
30 ALL DAMS	------	-	-	84	--------	--	67	13495	3.7	502		96	DIFF.	ALL	DAU	& HERD	DATA	
DIFF 23-18-24	------	-	-	1	--------	--		465	.0	15		1		103	17		203-	6
HERD CODE																		
32500591	1855980	-	3	84	10-10-35	305	3	15806	3.3	527								
32500591	3284006	A	3	82	10-10-50	305	1	15977	3.7	599			32	15528	559	35	15667	564
32430860	2497395	-	3	80	7-31-44	302	3	16986	3.7	623								
32500591	3272791	-	3	90	11-30-49	305	2	15870	4.1	646			36	15667	564	36	16167	582
32430860	2497395	-	3	80	7-31-44	302	3	16986	3.7	623								
32500533	3349862	A	3	81	11-28-50	305	2	18543	4.0	737			32	13528	487	41	15833	570
32430860	2425344	-	3	86	12-18-41	291	6	12169	3.7	452								
35640927	35AA84269	-	3	90	7-24-50	301	2	14275	3.8	527			26	13654	483	39	14286	522
33260865	2497390	-	3	80	6-30-44	302	2	16869	3.7	632								
32500533	3546972	A	3	85	11-28-50	305	1	18549	4.0	736			32	13528	487	41	15833	570
33260867	2395055	-	3	87	11-30-41	301	6	11674	3.6	417								
33500534	3152765	A	3	90	8-29-48	305	1	9073	3.3	296			25	13345	465	45	14542	475
35170985	2472904	-	3	87	11-29-43	295	7	12760	3.7	467								
33160113	2923941	-	3	83	11-03-47	305	1	11421	3.7	426			23	14167	493	35	14345	432
33180742	2472904	-	3	87	11-29-43	295	5	12760	3.7	467								
35110643	2923342	-	3	85	11-03-47	305	5	13519	3.8	513			27	14474	505	37	15142	512

Figure 9.6. An example of the Proved Sire Record, developed by the United States Department of Agriculture, which uses production records from the DHIA Testing Program.

tion level similar to that of the dams and/or contemporaries

If a sire's daughters only approximately equal their dams and/or contemporaries in production the sire may continue to be used in herds with production levels similar to that of the dams and/or contemporaries until a better sire can be obtained

If a sire's daughters fail materially to equal their dams and/or contemporaries in production the sire obviously should not continue to be used in herds with production levels similar to that of the dams and/or contemporaries If however a sire's daughters fail to equal high producing dams and/or contemporaries the sire may prove useful in herds with production levels lower than that of the dams and/or contemporaries

Additional Facts Helpful—Available averages of contemporaries and for the herd provide data for comparing the production level of the daughters with that of their stablemates and that of the herd (See notes 9 and 10 below) These averages together with the feeding index (See note 8) provide some indication of the average producing ability of the herd and the environmental conditions of the herd

These supplementary data are only *indicative* and *every effort* should be made *to further supplement the proved sire record* with *additional information* gathered from the herd in which the dams and daughters made their records In the column headed "CAR" (Conditions Affecting Record) are listed codes of conditions which have affected the records of individual cows Further information on such records should be obtained from the owner's herd record book

These notes refer to the small superior numbers on the proved sire record

1 "AB Service —If a sire has been in AB Service the code numbers of the state and stud are listed The first two digits of the code refer to the State in which the stud is located the second two digits are the code number of the stud within the State

2 "Records from States"—Data under this heading indicate the states from which records of daughters included in the proved sire record were obtained together with the number of daughters from each state The first two digits indicate the state the last three digits indicate the number of daughters from the state

3 "Summary"—Data in the top portion of this column refer to the number of comparisons and the total number of daughter records included in the proof A brief summary of the proof as indicated by data such as "Diff 0012 0008 0012" This indicates that 12 of the daughters whose records are included in the proof exceeded their dams in milk production Eight of the daughters had an average milk test exceeding that of their dams and 12 of the daughters exceeded their dams in butter fat production The bottom portion of the column under the subhead "Herd Code contains the herd code number of the herd from which production records of the dams or daughters were reported

Dam and daughter comparison data are single spaced with a double space separating different pairs On the first line of each group are data for the dam On the second line are data for the daughter

Once the first 21 comparisons are listed when a sire is reproved with more than 21 comparisons only the summary data are listed in the proved sire record

4 "AB"—The letter "A" in this column indicates the daughter is an AB progeny

5 "Breed"—Breed of dam and daughter is indicated by the following code

1 Ayrshire	6 Milking Shorthorn
2 Guernsey	7 Red Dane
3 Holstein	8 Other
4 Jersey	9 Red Poll
5 Brown Swiss	

6. "Type"—If available, the type score of each animal is listed in this column.
7. "CAR"—Conditions Affecting Record—Conditions affecting the record are indicated by the following codes:

2 Incomplete; sold	7 Sickness
3 Incomplete; died	8 Abortion
4 Injury	

8. "Feeding Index"—When feed data have been reported, a feeding index has been calculated in an attempt to estimate the feed input of the daughters of a sire and of their dams. Feed fed and feed requirements have been calculated on a net energy basis. To obtain the index, estimated net energy fed has been divided by the total estimated requirement for maintenance and production. Theoretically, an animal with a feeding index of less than 100 indicates the animal was fed below requirements.
9. "305-Day Contemporary Average"—Data under this heading indicate the average standardized production of paternally unrelated stallmates of the animal that completed production records in the herd concurrently with the record(s) of the daughter listed. The contemporary average provides some indication of average producing ability of the stallmates and the environmental conditions of the herd during the approximate period the lactation record(s) of the daughters listed was made.
10. "Yearly Average"—Data in this column indicate, on a cow-year basis, the yearly average production of the entire herd. The yearly average provides some indication of the producing ability of the herd as a whole and of the environmental conditions of the herd during the approximate period the record(s) of the daughters listed was made. The yearly herd averages in this proved sire record have been increased by 9 percent, so that they may be more comparable to the standardized lactation average data included in the record.

It should be remembered that a "proof" on a bull does not in itself make the bull more valuable. It merely provides information on the producing ability of his daughters, which is as likely to be below the breed average as above it. Detailed study of a proof is necessary to properly evaluate a bull.

The comparison of the performance of the daughters of a bull with cows in the same herd is a valuable tool in evaluating the transmitting ability of a bull. Daughters of a bull kept in a herd of low production cannot be expected to perform as well as those kept in a herd of high average production, because of the differences in environment. It is usually estimated that about 10 per cent of the differences between herd averages for production is due to heredity, and 90 per cent due to environment. There is, of course, a lot of variation in this average figure when two individual herds are compared. This estimate of 10 per cent applies to large groups of herds from populations on which records are available, such as herds on D.H.I.A. It is good planning to also use a bull proved to raise production in high producing herds, even in lower producing herds. Then, if there is an improvement in management, inherited producing ability is less apt to be a limiting factor.

Reporting systems which adjust production records for the production of stablemates, year of calving, and season of a calving provide increas-

ingly reliable information in comparison to unadjusted records Research is continuing on the proper factors to use in making these adjustments, and they may be expected to be used more frequently in the future An example of how milk production may vary during different seasons and years is presented in Figure 9 7 Information taken from a herd average, or a single record, which is greatly influenced by one of the periods of high or low production would not be representative of the herd or animal under study

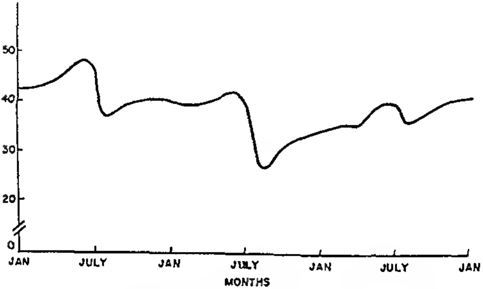


Figure 9 7 Variations which might occur in the average production of a herd in different seasons and years

Indexes for evaluating bulls. A number of mathematical expressions have been developed to provide an estimation of the transmitting ability of bulls in terms of production of milk or fat These are based on the fact that the sire contributes one half of the *heredity* of his *offspring* Their purpose is to reduce production information to a single figure, to make comparisons between bulls easier The simplest of these is the *Daughter Average* This is simply the average production of all the daughters of a bull expressed in terms of milk and fat and per cent fat Usual adjustments as mentioned above may be made in the original data When all the daughters of a bull are in one or two herds, this average is subject to considerable influence due to environment When there are large numbers of daughters (50 or more) in many herds, as is frequently the case in artificial insemination, it gives information which is quite adequate, particularly when compared with the breed average

The *Equal Parent Index* is another expression of the transmitting ability of bulls It is calculated by the following formula

Equal Parent Index = (*daughter's average production*) + [(*daughter's average production*) − (*dam's average production*)]. This index brings in the factor of the production level of the cows to which a bull was bred. It can provide a somewhat more accurate picture when a bull is used on a group of cows with an average production appreciably higher or lower than the breed average. In applying this index, it must be remembered that only a part of the differences in production between the daughters of different bulls can safely be assigned to heredity. The relative conditions of environment for the dams and daughters should always be carefully considered.

A *Regression Index* is sometimes used.

This is simply the *equal parent index* divided by 2. This regression index provides a smaller figure than the equal parent index, and one which more closely represents the production level which may be expected from the daughters of a bull when he is bred to dams of known producing ability.

The recent use of adjustments in the records of the daughters of a bull, based on the performance of stablemates, is growing in favor. The stablemates' performances are provided by U.S.D.A. proofs, shown in Figure 9.6. Properly used, this should be more reliable than the indexes previously mentioned, since, by adjusting for stablemates, it is affected by the enviroment in which the bull's daughters were kept. As more experience is gained, other factors, such as length of dry period for second and later lactations, length of pregnancy during the lactation, and season of calving, will be probably adjusted for routinely, in reporting production information on the progeny of a bull. When stablemate adjustment is based upon animals calving in the same six-month or shorter period, season of calving is automatically included.

Whatever method is used to evaluate the producing ability of the offspring of a bull, every effort should be made to be sure that all tested daughters are included, and that the information used is as complete and accurate as possible.

Type information on progeny. The purebred associations all make information on the classification score of the daughters of registered bulls available, if the bulls are included in their type-appraisal programs. Data on type are used more directly, and without the adjustments applied to production data. Average total classification score is frequently used as a general appraisal of the type of a bull's daughters. The approximate percentages of classified animals falling in the various brackets may be useful as a guide to the relative merit of the type of a given animal or as an average type score in a herd. During a recent year, animals were classified according to type in approximately the following percentages: Excellent, 1 to 3 per cent; Very Good, 13 to 30 per cent; Good Plus, 41 to 42 per cent; Good, 25 to 35 per cent. However, the

score obtained from the various type categories must be considered carefully in evaluating the strong points of type among the offspring of a given bull. When information on the type of a bull's daughters is not available, it is sometimes possible to see them and evaluate their type according to one of the procedures covered in Chapter 7.

Information on Individual Animals

When enough information is available on the performance or characteristics of individual animals, it is very useful in evaluating them for breeding purposes. A number of factors must be considered in making sound comparisons among the animals being considered.

Production information on individual animals. Production information is usually the best source available for evaluating female animals. The sources of production information have been previously discussed. Careful evaluation of production records to account for environment is necessary. Again, a number of mathematical approaches have been developed to make the appraisal of individual females more reliable. They are designed to account for environmental differences which influence production records.

A *Probable Real Producing Ability* for a cow may be calculated by the following formulas.

For a *single* record on a cow: Probable Producing Ability = Herd Average + $r \times$ (cow's record − herd average).

When a number of records are available, all should be used, since they greatly increase the reliability of the estimate. Then the following formula is used:

Probable Real Producing Ability = Herd Average + $\dfrac{Nr}{1+(N-1)r}$ (Cow's average − Herd average)

N is the number of records available and r is the repeatability, usually about .4.

For example: A cow has three records averaging 15,000 pounds of milk in a herd averaging 13,500 pounds, 2x 305d M E (2x = milked twice daily, 305d = a 305 day lactation, M.E. = mature equivalent.) What is her probable real producing ability?

$$13{,}500 + \frac{3 \times .4}{1+(3-1)\times .4}\,(15{,}000 - 13{,}500)$$

$$13{,}500 + \frac{1.2}{1+(2\times .4)}\,(1{,}500)$$

$$13{,}500 + \frac{1.2}{1.8}\,(1{,}500)$$

$13{,}500 + (.67 \times 1{,}500)$

$13{,}500 + 1{,}005 =$

14,505 pounds, the Probable Real Producing Ability of this cow.

Calculations similar to those for probable real producing ability may be used to calculate a breeding value for an animal. In this instance, the factor for heritability (h) is substituted for probability (r). The calculated breeding value of a cow may be obtained by use of the following formulas.

For a single record:

Probable Breeding Value = Herd Average + $h \times$ (Cow's Record − Herd Average).

Increased accuracy may be obtained when a number of records are available on a cow. The formula is modified to include several records as follows:

Probable Breeding Value = Herd Average + $\frac{nh}{1+(n-1)\,r}$ (Cow's Average − Herd Average)

Here n = number of records, h = heritability, and r = repeatability.

For example, consider a cow which has an average production for two lactations of 600 pounds of fat, in a herd which averages 500 pounds of fat, 2x 305d. M.E. What is her Probable Breeding Value?

$$500 + \frac{2 \times .25}{1+(2-1)\,.4} \times (600-500)$$

$$500 + \frac{.5}{1+(1 \times .4)} \times 100$$

$$500 + \frac{.5}{1.4} \times 100$$

$$500 + (.357 \times 100)$$

$$500 + 35.7 =$$

536 pounds of fat, the Probable Breeding Value of this cow.

Use of the above procedures makes possible comparisons of animals in the same herds on a sounder basis than by just comparing individual production.

Type. Type classification for bulls is a part of the program of most of the breed associations. However, because of the effect of secondary sexual characteristics, the appearance of a mature bull is frequently not a reliable indication of the type of his daughters. Many factors of environ-

ment may also affect the type score of a bull but have no influence on the type he transmits to his offspring.

Type characteristics of females are more apt to give an indication of what may be expected of their offspring. Repeatability of type classification of dairy cattle is about .35 to .45. Heritability of type classification is approximately .30.

If it is considered helpful, calculations similar to those presented on determining probable real breeding value for production may be used for evaluating the transmitting ability of an animal for type.

Information on Ancestors and Close Relatives

Frequently, information is easiest to obtain on the ancestors of an individual. This is particularly true when it is desired to make decisions on young animals. When complete and accurate, this information gives a good indication of the characteristics making up the inheritance of an individual. Information on ancestors is commonly presented in the form of a pedigree such as that shown in Figure 9.8. There are several points of caution which should be observed in evaluating pedigrees. Environment should always be considered. Emphasis should not be placed on outstanding individuals several generations back. It should be remembered that an individual in the third generation back contributes only one-eighth of the genetic make-up of the animal in question. An animal in the second generation contributes one-fourth and, of course, each parent contributes one-half. Geneticists believe that little is to be gained in evaluating pedigrees from study of more than three generations. Occasionally an animal will appear several times in a pedigree, which has the effect of increasing its genetic contribution in direct proportion to the number of times it occurs. It may thus be a more important factor than its distance from the present would indicate.

One should be certain that information in a pedigree is unselected and the production records and type classification are included for all animals and lactations for which they are available. Irrelevant information in regard to the actual performance of an animal should be pulled out. Sale prices of the individual or its close relatives are not reliable measures of producing ability. Placing in shows indicates good type in an animal only in relation to the competition in the particular show. Outstanding individuals with only slight relation and not in direct line of descent are sometimes mentioned in pedigrees. They should be considered only to the extent that the two animals may have inherited the same genetic material.

In some instances, information may be available only on full or half-sisters of an individual. If there are sufficient numbers of these relatives, this can be very helpful. However, again it must be remembered that

NEEDMOR SOVEREIGN T. 135021

HIS SIRE
ROYAL'S TAMARIND OF LEE'S HILL 76059
Classified "Very Good
31 daus 38 rec avg 11303M 4 4% 497F
31 dams 110 rec avg 11074M 4 1% 454F
+229M + 3% +43F
Daus in above proof are A I progeny only
44 classified daus avg 64 2%
9 'Ex.", 16 "VG', 12 'GP , 7 "G"
Sire, 1st prize Sr Get of Sire, Ohio S S & E S Exp , 1957 Sire, 1st prize Get of Sire Ohio St Show, 1956
His daughters include
S V F Tamarind Phydella Harriet
9y 365d 3X 22498 4 4% 1003 2
R. H Y. Jane's Chloe
4y 365d 3X 19629 4 8% 952 7
(Former Honor Roll)

JANE'S ROYAL OF VERNON 28594
Classified 'Excellent"
84 tested daughters
58 daus avg 13,315M 567F
56 dams avg 12,037M 511F
+1,278M +56F
9 times 1st Sr 'Get' Waterloo
His ROP Daughters include
Royal's Rapture of Lee's Hill 'Ex '
10y 365d 3X 34669M 4 2% 1465 0
(Former National Champion)
Royal's Gina of Lee's Hill 'Ex "
10y 365d 3X 28439 4 7% 1359 0 (Honor Roll)
MARINDA JANE OF LEE'S HILL 90074
Classified "Ex " 11y 365d 3X 24281 4 6% 1117 2
6y 365d 3X 18235 4 6% 652 8
Gr Ch Waterloo, 1947-51-52

HIS DAM
ORANGEVILLE TAURUS ZEMA 270495
Classified 'Excellent '
HIR Records
4y 305d 2X 13039 4 5% 568 6
3y 266d 2X 9257 4 6% 426 9
4y 365d 2X 14415 4 58% 860
5y 326d 2X 12010 4 48% 540
Md Reserve State Bellringer Aged Cow '59

ORANGEVILLE GALLANT'S TAURUS 69978
Proven 8 dau-dam comparison +2611M + 3% +148F
His daughters include
Orangeville Taurus Rita Girl
7y 365d 3X 18763 4 4% 626 1
Kay-Al's Trudy
5y 306d 3X 18148 4 5% 623 3
ORANGEVILLE ZEMA 164067 Classified 'Good Plus'
HIR Records
2y 365d 2X 12136 4 3% 526 5
4y 330d 2X 11281 4 4% 503 5
7y 305d 2X 12463 4 1% 513 9
3y 305d 3X 11054 4 4% 487 1 ROP

Figure 9.8 An example of a typical pedigree, in this case a Brown Swiss bull. Courtesy Maryland-West Virginia Bull Stud

there can be tremendous variation in the inheritance of even full sibs. Full sisters carry 50 per cent of the same heredity, on the average, while half-sisters carry 25 per cent. Records on the close relatives of a cow should be given weight in line with the degree of relationship which exists between the animals. Formulas are available, in the references noted at the end of the chapter, for calculating probable real breeding value of individuals from a number of combinations of relatives and ancestors.

Information from analysis of cow families. Emphasis in dairy-cattle breeding is usually placed upon the sire, since his progeny are so much more numerous. Cow families may, however, also be studied. This can be done by making comparisons of the performance of the offspring of the foundation cows of a herd for as many generations as they are continued in the herd Some striking differences in cow families may be discovered by this type of study. However, the influence of any individual cow becomes diluted very quickly by the use of different sires in succeeding generations. To be meaningful, a fairly close relationship must be maintained within a cow family. Again, one should avoid putting too much emphasis on individuals far back in the ancestry of an animal.

CHOOSING INDIVIDUAL ANIMALS

When all of the information possible has been obtained, the decision must be made as to which animals are to be used to provide herd replacements or breeding stock for sale This decision cannot be rendered with total certainty The variables which contribute to the uncertainty have been mentioned previously The breeder must weigh all the information and make the best decision possible It should be remembered that considerable information indicating that an animal has the ability to transmit is better than scantily supported outstanding individual performance

The aims and objectives of the herd are important in determining the way in which selection is made Selection of a herd sire should involve the highest standards possible, since he has such a great influence on the future of the herd Standards of selection for females to remain in the herd must be kept in line with the availability of replacements When every maturing heifer is needed as a replacement to maintain herd size, selection cannot of course be as critical as in the case of cows with long productive lives However, when cows are kept for longer periods, the generation interval is increased, which reduces the opportunity for genetic change

The more precise the desired characteristic for which selection is made, the more rapid the progress which may be expected.

Standards for Culling

The preceding discussion has emphasized the selection of outstanding animals for breeding purposes. This is of particular importance when selecting sires and the dams of sires. Here the best animals available are considered. In practical herd operation, the minimum standard of performance for females is an important factor. Culling may be based upon minimum standards in each area of concern or upon some basis in which a combined "score" for all the important factors is used. Some percentage of herd average or, in outstanding herds, the breed average, may be selected as the basis for culling. For example, if culling is based on fat production in a herd producing an average of 500 pounds of fat, animals producing less than 375 or 400 pounds of fat may be slated for replacement. In purebred herds where type is important, similar standards may be established.

It may be desirable to provide some leeway in standards for first-calf heifers to get a more accurate appraisal of their real abilities. Usually, by the first two or three months of the second lactation, it will be evident whether improvement has been made over the first in production or changes in type characteristics due to greater maturity. Other considerations in culling cows are discussed in Chapter 13.

Systems of Breeding

After satisfactory animals have been selected, the way they are used in a breeding program may have a great influence on the over-all contribution they make to a herd.

A number of terms in common usage refer to breeding programs. Most of them indicate the degree of relationship of animals to be mated.

In-breeding and *close-breeding* refer to mating of individuals more closely related than the average. Close-breeding may include matings as close as full or half-sibs, sire and daughter, or dam and son.

Line-breeding refers to mating individuals less closely related, and is usually used to increase the genetic contribution of an outstanding individual, or family, to a herd.

This general type of breeding tends to increase the frequency of occurrence of similar characteristics in the offspring, and intensifies the expression of the qualities present. It was the basis for the establishment of our present breeds and some outstanding families within the breeds. The offspring resulting from the mating of related individuals tend to be more homozygous for all characteristics.

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Number of Characteristics Selected For

Most rapid progress can be made in a breeding program by selecting for one characteristic When two characteristics are inherited in close relationship, considerable progress may be achieved in both of them An example of this would be total production of milk and total production of fat Since body type and high production of milk are not closely associated in inheritance, selection for both of these will result in relatively slow progress in either one The herd owner must decide the area in which the herd needs most improvement and make his decision on the characteristics to be emphasized in selection accordingly If good type will bring more return it should be emphasized If higher production will increase income to a greater degree, it should be given greater importance in selection In many herds particularly purebred ones both type and production are important and selection for both will be made Selection for either type or production should not be made at the expense of serious loss in the other

There are of course opportunities to base selection upon specific factors within the broad aspects of type and production That is udder conformation levelness of rump or breed character may be emphasized as a single component of type Either total milk or total fat or fat percentage may be a basis for major emphasis in selecting for production

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The mating of animals with a high degree of homozygosity for desirable characteristics can have excellent results. However, undesirable characteristics are intensified just as rapidly. For this reason, intensive inbreeding is shunned by most breeders. When inbreeding is practiced, the breeder must recognize the need for careful culling of those animals showing undesirable characteristics. Losses from lethals, if present, will be increased.

Outcrossing, *outbreeding*, and *crossbreeding* are terms which refer to mating individuals less closely related than the average of the population. Crossbreeding implies the mating of individuals of different breeds. This type of breeding program makes it possible to take advantage of outstanding genetic material from a variety of sources, and any possible hybrid vigor. While the danger of undesirable characteristics is minimized, there tends to be less uniformity in the offspring.

The offspring of widely unrelated animals frequently exhibit unusual vigor and producing ability. This is referred to as "hybrid vigor" or *heterosis*. When the mating of a bull with several related females results in offspring with consistently desirable characteristics, the word *nicking* is sometimes used to describe the situation.

Some research has been conducted on the results of cross-breeding and more is underway. In general, the results have been in line with the quality of the cattle used, with some heterosis. That is, the offspring have performed slightly better than the expected average of the parents.

Grading-up is the term used when purebred bulls are used on grade herds. Fairly rapid progress may be achieved in obtaining the characteristics of a given breed in a grade herd. The fourth generation in such a program will carry over 90 per cent of the blood of the breed in question. Although dairy cattle closely approximating purebreds may be developed in this manner, they cannot be registered

Selecting Animals for Purchase

When purchasing animals or selecting herd replacements, the top producing animals in a given herd and their offspring should be given preference. Cows tend to retain their same relative position in the producing pattern of a herd when management or environmental conditions change.

Approximately 90 per cent of the differences in production between herds may be accounted for by management. Therefore, the top animals in a low producing herd frequently do an outstanding job when placed under good management conditions. The expected potential for these animals is greater than that of mediocre animals in herds of high production.

Developing a Selection Program

For most rapid progress, each dairy herd, used for breeding purposes, should have an organized program of selection and breeding. There are numerous approaches to such a program. The principles which follow will be helpful in developing a good operating procedure. In following this or any other breeding and selection program, frequent review is important. The background information, and the progress made, should be brought up to date at least each six months.

The first step is to obtain and organize all the pertinent information available on each animal. From this information the females in the herd can be ranked according to their estimated breeding value. Standards and goals (of production, type, and so forth) should be established for the herd.

When a reasonable set of standards is applied to a herd, animals usually fall into three groups. (1) Animals which are estimated to be of sufficient value as foundation stock that it is desirable to raise their offspring. (2) Animals which are estimated not to possess the characteristics which make them desirable for breeding stock, but which have the capability for sufficient production that they may be economically maintained in the herd. (3) Those animals which are estimated not to be desirable for breeding stock, and do not produce well enough to make an economic contribution to the business.

Animals in the first group should be mated to the best bull available to the herd. Due attention should, of course, be paid to correcting areas where improvement is especially desired, or points in which the herd may be weak.

The time at which selection of young animals is to be made and the need for replacements in the herd determine the breeding program for animals in the second group. If the calves from the animals in the second group are to be discarded or raised for meat, they may be bred to any bull. However, if there is a chance the calves will be raised for dairy purposes, the best bull available should be used on these cows. In some herds all heifers are milked for at least one lactation, and if a bull with ability to transmit outstanding characteristics is used, some offspring from cows in the second group may make satisfactory animals.

Cows in the third group should be culled as rapidly as practical.

Selecting Young Bulls for Artificial Insemination

In addition to using naturally proven bulls, many artificial breeding studs have developed a program of proving young bulls under conditions

of artificial insemination. The usual procedure is to select about four bull calves of expected high transmitting ability. Semen from these calves is used to breed a large number of cows (usually about 1,000) as soon as it is available. The bulls are then set aside until production records are available on their daughters, and the one or ones showing the most promise are brought into service. This system costs about as much as the average price paid for naturally proven sires. However, it has the advantage of practically assuring the availability of desirably proven bulls. It also utilizes the facilities of artificial insemination on large groups to prove young bulls. The risk to individual herd owners from using these unproven bulls is small, since they are selected for good characteristics to start with, and only a few breedings are made in any one herd. With artificial breeding groups assuming such a large proportion of the breeding work, they have a definite responsibility for proving young bulls.

There are a number of methods for selecting bull calves to be sampled. One is to locate several outstanding cows in the higher producing herds of the breed. If they are of satisfactory type, they are then bred to semen from bulls already proven to be well above average in transmitting ability. Bull calves resulting from these matings then are selected and brought in for sampling as previously described.

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10 Diseases and Parasites of Dairy Cattle

DAIRY cattle, like all other animals, are susceptible to a variety of disorders and diseases. Some of these are metabolic or functional in nature and some are the result of infectious organisms

DISEASE PREVENTION

Prevention of disease, wherever possible, is the most effective and economical treatment. Well-fed, vigorous animals kept in clean, dry, and sanitary surrounding provide the first step in a disease prevention program.

Reducing the possibility of introducing new infections is important. New animals entering the herd should be isolated until they have been examined and found free of common diseases and until the incubation period for diseases has passed. Travel between herds or units where there is a suspicion of infection should be permitted only when footwear and clothing are changed or properly washed. Contact between different herds over pasture fences or via drainage from one pasture to another is undesirable.

Cattle should be kept away from streams which flow through other farms where livestock are kept. Rats, other rodents, and insects which frequently carry infections should be eliminated. A regular program of vaccination for those diseases that have vaccines should be followed. A program of routine examination and preventive treatment worked out with a veterinarian is more economical than the cost of treatment of disease and the losses resulting from it. Dairymen can operate effectively only with a well-designed disease prevention program.

METABOLIC OR FUNCTIONAL DISEASES

These are the result of failure of a body function to perform normally. Most of them respond to some form of treatment. Management for prevention is frequently possible.

Bloat. Bloat is a condition in which the animal is unable to expel rumen gases through the esophagus and mouth in the normal manner. The rumen becomes greatly distended, protruding on the left side first and then rounding out on both sides of the abdomen. Figure 10.1 is a picture of an animal in severe bloat. Death occurs in severe cases from unknown causes, which may be suffocation due to the gas pressure or absorption of toxic substances. Bloat occurs most frequently in cattle grazing lush legume pastures. It also occurs with animals under feedlot conditions, particularly those fed a highly concentrated ration with ground forage.

An intensive research program has been underway for several years on this disease, which occurs throughout the country and results in tremendous losses to the dairy industry. These losses occur both directly as a result of afflicted animals, and as a loss of potential production where bloat-causing crops are not grazed.

The specific cause of the disorder is not known. Theories have been advanced that some poisonous substance inhibits normal function of the nerves supplying the digestive tract. Others feel that a physical problem is involved. The rumen is usually filled with a viscous froth which traps much of the gas present. Figure 10.2 shows the difference between rumen contents from a normal and a bloated animal. The bacterial population of the rumen is probably involved.

Treatment consists of the oral administration of a material affecting surface tension to break the froth and release the gas Corn or soybean oil are effective agents in this regard. One-half pint to a pint of this material is commonly given. Introduction of a tube through the mouth and into the rumen will allow for the escape of gas and serve as a route for administering a treatment. In severe emergency cases, a puncture, to allow the gas to escape, may be made into the rumen in the area between the hip and the ribs just below the loin This is done ideally with a trocar and cannula, however, any handy knife may be used.

Many procedures have been proposed for the prevention of bloat. None are completely satisfactory. Feeding small amounts of a number of antibiotics for a few days before and during pasturing on bloat-producing areas has been helpful The effectiveness of single antibiotics usually disappears after a few days. Feeding a number of antibiotics in a mixture or in succession prolongs the effective period of prevention. Limiting pasture time drastically or feeding cattle before turning on

pasture so that consumption is reduced is sometimes helpful. Also pasture seeding mixtures can be used to replace legumes with grass, if the grass will yield well in the area.

Parturient Paresis. Parturient paresis (milk fever) is a metabolic disease of lactating cows occurring at or shortly after the beginning of lactation. The gross symptoms are, first, muscular spasms, showing increased irritability of the central nervous system. As the condition be-

Figure 10.1. A dairy steer showing the swelling of the abdomen caused by severe bloat. Courtesy N. L. Jacobson

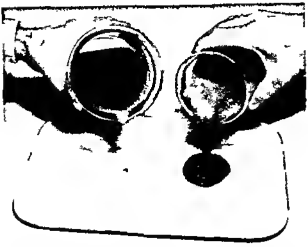

Figure 10 2 A demonstration of the physical characteristics of fluid from the rumen of a normal animal (left) and from the rumen of an animal suffering from bloat (right) Courtesy N L Jacobson

comes worse, there is paralysis and unconsciousness The animal lies in a typical position, with the feet drawn up to the body and the head turned to the side, in an attitude of sleep Death frequently occurs if treatment is not administered There is a major reduction in the calcium level of the blood stream, which accounts for the observed symptoms The underlying cause is not known It has been theorized that the para thyroid glands which control the calcium level in the blood may be unable to adequately provide for the high demands for calcium suddenly occurring with the beginning of lactation Susceptibility to milk fever is apparently inherited, since it is more prevalent in certain breeds and families

First calf heifers seldom have milk fever and its occurrence at the second lactation is limited Once a cow has the disorder, she is apt to repeat it at each successive calving

Treatment consists of the intravenous *injection of a calcium salt,* usually calcium gluconate, which should be made slowly to prevent heart block. Recovery is rapid and dramatic. The condition may recur and several treatments are frequently necessary

The feeding of 20 000 000 units of vitamin D daily for seven days before calving has proven to be helpful in preventing milk fever in a number of cases It is recommended for animals with a history of the disease Accurate records and careful observations are necessary to correctly establish the time to start the procedure Feeding vitamin D should stop at the end of seven days even if the cow has not calved It may be continued for a day or two after calving if necessary to complete the seven-day period

Bovine Ketosis. Ketosis or *acetonemia* occurs in dairy cattle usually during the first six weeks of lactation. High-producing cows are particularly susceptible. It is characterized by general disability, lack of appetite and decreased milk production. Nervous symptoms may be present. An odor of acetone may occur in the breath, urine, and milk. The level of ketone bodies (acetone, acetoacetic acid, and Beta-hydroxybutyric acid) is increased in the blood, urine, and milk. The glucose level in the blood is reduced. Death is not common, but production is usually drastically curtailed.

Again, the specific cause is not known. The adrenal and pituitary glands show typical signs of stress, and exhaustion of these glands has been suggested as being involved. It is apparent that there is an impairment in normal utilization of nutrients available to the body. It may be that the breakdown is in the metabolism of fatty acids.

Treatment may be accomplished by the intravenous injection of glucose, or by the intramuscular injection of the hormones ACTH or cortisone, or cortisone derivatives. Repeated injections of glucose are usually necessary. Hormone injections may also need to be repeated. Drenching or feeding of propionate or lactate salts, glycerol or propylene glycol is helpful in maintaining control of ketosis.

There is much variation in the occurrence of ketosis between different herds, and in the intensity with which it is present in given herds during succeeding years. Several specific mineral and vitamin deficiencies have been suspected of contributing to ketosis. None have been proved to be directly responsible. It may be that stress, placed on the animal because of nutrient deficiencies, contributes to the condition causing metabolic failure.

Preventive measures may be taken which will reduce the incidence of ketosis. Feeding a ration which increases blood sugar is helpful. Because of the activity of bacteria in the rumen, the feeding of sugar or feedstuffs high in sugar is of little value. Feeding one-fourth to one-half pound of propionate or lactate salts daily for approximately six weeks before calving and continuing for a similar period after calving has proven helpful in reducing the incidence of ketosis.

Careful attention to an adequate diet during the dry period may be helpful. Maintaining the cow on full feed during the calving period to the extent that she will eat, and increasing the level of grain feeding as rapidly as possible until the nutritive requirements for production are met, will reduce stresses from a deficiency of energy which may contribute to ketosis.

Low blood magnesium (grass tetany). Lowered blood magnesium in cattle, usually accompanied by lower calcium levels, also causes symptoms of disruption of the central nervous system. The victims stagger and apparently lose control of muscular activity. They may walk directly

into walls or fences. In severe cases, the animal collapses and dies after a period of convulsion. This condition is most frequently observed in cattle following a period on lush spring pasture, hence the name "grass tetany." However, it may occur at any season of the year and under barn-feeding conditions. The application of stress, such as calving or severe exercise, seems to bring on the symptoms.

Treatment consists of the intravenous injection of a mixture of magnesium and calcium salts. As with milk fever, recovery is dramatic.

Because of the occurrence of disease in varying intensity in different areas and in different years, it is thought to be associated with the composition of the feed. Apparently, some chemical interaction with magnesium occurs which makes it relatively unavailable from the feed, or increases the animal's requirements. The disease frequently occurs on feed containing amounts thought to be adequate for normal nutrition The supplying of supplemental magnesium in the ration may be helpful, but frequently has not proved effective.

Udder edema. This is a condition in which fluid accumulates in the tissues of the udder and surrounding areas. The fluid is located under the skin and not in secretory tissue. In severe cases, swelling may extend completely across the floor of the abdomen. It may also occur around the rear udder attachments. Udder edema usually occurs just prior to and following calving. Some animals carry swelling throughout most of the lactation. The condition appears to be more noticeable with first calf heifers, however, susceptible animals tend to repeat at each calving. Research results indicate that susceptibility to udder edema is at least partially inherited.

In addition to intense discomfort to the animal, severe udder edema results in stretching of the udder supports, strutting of the teats, and pendulous udders. Udders so affected are most difficult to milk and are susceptible to injury and disease.

No satisfactory treatment is available. Treatment with massage and hot and cold applications, as sometimes prescribed for any swelling, may be of some benefit. Preventive measures are not known. Extensive research has shown that the kind or amounts of common feedstuffs do not affect the incidence or severity of udder edema. Studies on proteins, salts, and other factors which influence the osmotic pressure of blood may provide a key to the solution of this problem.

Tumors. Cattle are afflicted with abnormal tissue growths in a manner similar to man. However, the frequency of involvement of given tissues is quite different.

Cancer of the eye is one of the most frequently observed. Its occurrence in Hereford cattle is by far greater than in other breeds, with cases in dairy cattle quite infrequent. The adrenal glands and the uterus are also subject to tumors, some of which are difficult to diagnose. A

limited portion of reproductive difficulties is probably associated with tumors. No good recommendations can be given for prevention or treatment. Surgery may be successful on superficial and benign tumors.

Irritation from ingested metal (hardware disease). This problem is probably more physical than physiological; however, it is a result of the eating habits of cattle. In the normal process of eating, large mouthfuls of concentrates and forages are consumed with only enough chewing to moisten them for swallowing. Any nails, pieces of wire, or other stray bits of metal contained in the feed are swallowed. These eventually work their way into the reticulum at the forward portion of the stomach. Muscular contractions of this organ force the sharp points through the wall of the reticulum. Nails or pieces of wire may penetrate through the diaphragm and even puncture the heart.

Symptoms of this difficulty include feed refusal and evidence of discomfort in the chest region. In some cases, relief may be obtained by elevating the front legs of the animal so that the object falls away from the forward area of the reticulum. This is usually temporary treatment. Frequently, the offending object can be removed by opening the rumen at the area between the hip and the last rib below the loin, and reaching into the reticulum with the hand.

The most satisfactory prevention is not allowing metal scraps to get into the feed. Magnets are available for oral administration, which remain permanently in the reticulum. They are designed to hold the sharp metal in a position so that it is not harmful. These are successful in some cases.

POISONOUS CHEMICALS AND PLANTS

A number of chemical substances to which cattle are exposed with varying degrees of frequency cause metabolic upsets with results ranging from mild symptoms to death. Some of the more common problems are considered here.

Molybdenum toxicity. In limited geographical areas, the soil contains large amounts of molybdenum, which is taken up by forages. Cattle consuming these forages show symptoms which include a profuse diarrhea, general weakness, anemia, and a fading of the hair coat. Death occurs in severe cases. Ten parts per million of molybdenum in forages will cause symptoms to appear after a period of several months. Twenty to 100 parts per million result in symptoms occurring within a week.

These forages should, of course, be discontinued. Feeding copper sulfate helps control the symptoms if the ration does not include over 15 to 20 parts per million of molybdenum. Copper sulfate may be supplied as one-half to one per cent of a salt mixture.

Fluorosis. Cattle do not tolerate an excessive intake of fluorine. Normal calcification of bones and teeth is interfered with in young animals. Excessive wearing of teeth and stiffness or lameness as a result of bone involvement occurs in older animals. In acute cases, diarrhea, loss of appetite and weight, and irritation of the digestive tract occurs.

There is no satisfactory treatment. The intake of fluorine should be kept below 30 to 60 parts per million in the total ration, for well-fed animals. Animals which are not well fed are somewhat more susceptible.

Exposure to fluorine poisoning is not widespread, but occurs in areas where dust from certain industrial processes falls on forage fields, or where excessive amounts occur naturally in soil or water. Mineral supplements which contain high levels of fluorine should not be used.

Selenium poisoning. Forages grown on soils high in selenium take up this element in amounts toxic to cattle. Soils with considerable selenium are most common in the western area of the country. Symptoms of selenium poisoning include rough horns, deformed hoofs, with eventual loss of the hoof, and loss of hair from the tail switch. Breeding difficulties may also occur.

Levels of 10 to 40 parts per million of selenium in the forage will produce chronic symptoms over a period of several weeks. Forages containing 200 parts per million or more will produce acute poisoning in a few days.

Nitrate poisoning. Nitrate poisoning results from the ingestion of excessive amounts of nitrates which are converted to nitrites in the digestive tract and absorbed into the blood stream. Here the nitrites tie up the oxygen-carrying capacity of the red blood cells. Symptoms include staggering, blue coloration of normally pink membranes, labored breathing, coma, and death. Abortions have been reported as a result of the grazing of weeds or high nitrate content.

Treatment consists of intravenous injection of methylene blue dye at the rate of 4 milligrams per pound of body weight to release the red blood cells from the nitrite. Repeated treatment may be necessary and is not successful if it is not given early, or if the tying up of oxygen-carrying capacity has become too extensive. Administration of a cathartic such as mineral oil may reduce the absorption of material remaining in the digestive tract.

One source of nitrates is the accidental consumption of nitrate fertilizers or other nitrate compounds. Several plants grown on soils high in nitrates take up excessive amounts of it and are also a source of poison. Oats and a number of weeds are particularly apt to be offenders Other forage crops have been observed to be implicated. A level of two per cent or more of the dry weight of forage in the form of nitrates renders it dangerous to feed

Arsenic poisoning. Arsenic poisoning occurs when cattle, usually ac-

cidentally, consume it from spray residues or material used for other control measures in farm operations. Symptoms include loss of weight, digestive upset, bright reddish color of internal membranes, and severe depression. Death occurs in many cases. Treatment is not usually effective.

Lead poisoning. Poisoning by lead compounds is nearly always the result of animals gaining access to residues from routine uses. Lead paints on structures or equipment used in painting are particularly frequent sources. Lead from sprays used on vegetable or fruit crops is sometimes involved.

Symptoms of lead poisoning include profuse salivation, inflammation of the digestive tract, refusal to eat, and diarrhea. In addition, lead has an effect on the nervous system, which results in a number of erratic movements. Lead is a cumulative poison and a series of small doses may be as dangerous as a single larger dose.

In some cases, when given early enough, epsom salts may act as an antidote, by rendering the lead in the digestive tract less soluble and absorbable.

Hyperkerotosis. Cattle which consume lubricating grease containing chlorinated naphthalene as an additive will exhibit the symptoms of serious vitamin A deficiency. Such greases on farm machinery should be kept away from cattle and should not be allowed to get into mixed feeds during processing. The difficulty involved is one of preventing the conversion of carotene to vitamin A, rather than a deficiency of carotene in the diet.

Prussic ocid poisoning. The leaves of a number of plants in which normal growth has been interfered with by frost, drought, trampling, or other means, frequently contain hydrocyanic acid (prussic acid) in quantities which are poisonous. Plants commonly involved are wild cherry and the sorghums, including Sudangrass and Johnsongrass. Young plants and second growth are most dangerous. Generally, plants made into hay or silage lose their poisonous properties, but occasionally a problem may develop with this material.

Sudangrass and other potentially dangerous forages should not be grazed until growth has reached 15 inches or more, or for a considerable period following frost, hail damage, or other injury to the crop. Cattle should not be allowed access to sorghum which has just started regrowth following harvest for silage.

Symptoms of prussic acid poisoning include rapid breathing, stupor, convulsions, blue coloring of normally pink membranes, paralysis, and death.

Treatment is frequently unsuccessful and must take place early to be effective. A mixture of sodium thiosulfate and sodium nitrite injected intravenously or into the abdomen may be helpful.

Poisonous weeds There are numerous poisonous weeds to which dairy cattle may be exposed Poisons from them result in a variety of symptoms including abortions, and various effects on the central nervous system, the digestive system and the respiratory system Fortunately, these weeds are not very palatable to cattle and are usually not eaten except when the animals are unusually hungry Management of pastures and fence lines to keep them free from weeds, and providing abundant good quality forage will prevent consumption of harmful weeds in most instances Many harmful weeds are somewhat regional in occurrence, and local authorities can help in identifying them

INFECTIOUS DISEASES

Mastitis. Inflammation of the mammary gland is the most costly disease affecting dairy cattle It is present to some degree in practically every herd The symptoms vary from a few flakes or clots in the milk to extremely abnormal milk and red, swollen, and feverish udders In severe cases, infection can become generalized and result in death The disease frequently results in partial or total destruction of milk synthesizing tissue in the quarter or quarters involved

Mastitis may be caused by a wide range of organisms which infect the udder The bacterium *Streptococcus agalactae* has been a particular common cause *Pseudomonas* organisms and yeasts are sometimes involved as well as *Staphylococcus* type bacteria. The infections are encouraged by improper handling of the udder in milking and by poor milking techniques Infectious organisms are abundant in the environment of the cow, and any injury to the delicate membranes lining the udder, or any severe chilling may allow them to set up an active infection.

Treatment alone will not control mastitis, and careful management must be continually emphasized Specific treatments should be administered only after examination has revealed the causative organism The treatment is determined by the organism involved. In some cases, antibiotics may be infused into the udder or injected intramuscularly This treatment should be given on the advice of a veterinarian

When antibiotics are used, the milk must be withheld from market for from three to nine days, depending upon the characteristics of the medication This is to prevent contamination of milk supplies by the antibiotics

It is an excellent practice to take samples of milk from all quarters of cows in a herd periodically, and have it examined for the presence of mastitis Most states maintain a laboratory for this work. Particular attention should be given to cows at the time of drying off, since intensive treatment may be most effective during this period

Management practices for the prevention of mastitis involve careful attention to proper milking procedures, as outlined in Chapter 2. Sufficient bedding, avoidance of overcrowding, and maintaining clear and unobstructed alleyways, all help to prevent udder injury. While it is difficult to eliminate the causative organisms from the premises, good sanitation is always important. Every effort should be made to prevent the spread of infection from one cow to another. Infected cows should be removed from the milking line. Indeed, this is required by the health authority in most areas. Cows with chronic mastitis are best sent to slaughter.

Contrary to the belief of some dairymen, there is no evidence that the kind or amount of concentrate fed has an effect on the incidence or severity of mastitis. Udders of high-producing cows are subject to more stress than those of low producers, and this may have some influence on the incidence of mastitis. Curtailing feed to reduce production is poor economy. The infection should be eliminated and normal feeding practices followed.

There is some evidence that certain individuals are more resistant to mastitis infection than others. This characteristic may be inherited and research is in progress to learn more about this possibility.

Brucellosis or Bangs Disease. Brucellosis is caused principally in dairy cattle by the organism *Brucella abortus* which was isolated by Bernard Bang of Denmark; hence the name Bang's disease. *Brucella suis,* and *Brucella melitensis* which infect swine and goats respectively, may occasionally be the causative agent in cattle. This disease is of particular concern because it is transmissible to humans, where it is known as undulant fever.

The chief symptom of brucellosis in cattle is abortion in the last third of pregnancy. Calves may be born very weak. Retained placentas and vaginal discharge are other symptoms. Diagnosis of the disease is usually made by an aglutination test of the blood, which indicates the presence of antibodies. The organism may also be isolated from an aborted fetus, or from the placenta or reproductive tract. There is no effective treatment. Individual animals usually develop an immunity to the disease after two or three abortions. However, the economic loss is severe previous to this. Brucellosis is highly contagious and spread by direct or indirect contact with products of the infected reproductive tract as well as in milk. Sexually immature females are generally resistant to the disease. Non-pregnant females and bulls seldom show symptoms of infection.

The federal and state governments have an active program for the eradication of brucellosis. This involves the testing of all animals and the slaughter of infected ones. As an aid to the program, an indemnity is paid to owners of cattle by each of the participating governments, so

that the state and federal governments help the owner cover any loss incurred in slaughtering infected cows. There are a number of approved variations in carrying out the eradication program which are utilized in different areas. Beef as well as dairy cattle must be included in an eradication program.

A majority of states have been certified modified brucellosis-free, which means that less than one per cent of the cattle and less than five per cent of the herds in that state are infected. In 1960, New Hampshire was declared free of brucellosis in cattle, the first state to defeat the disease.

Brucellosis is prevented by vaccination of all calves between the ages of four and nine months. This practice should be routine in all herds. However, it must be emphasized that immunity by vaccination is not absolute. Considerable variation exists in the reaction of individual animals. A test-and-slaughter program for mature animals is necessary, in addition to calfhood vaccination, to eliminate the disease. Contact with animals or herds where there is a possibility of infection should be prevented. All new animals coming into a herd should be tested for brucellosis.

A "ring test" for use on milk has been developed which is of help in locating infected herds. This test is usually performed on the mixed milk from one or a number of herds. Follow-up work when infection is indicated is necessary to locate the specific herds or animals. This test is an aid in detecting infection, but cannot be relied upon for complete control since many animals not giving milk are susceptible.

Bovine tuberculosis. Tuberculosis organisms affect cattle as well as humans and birds. Three distinct types of organisms are known which are associated with these three species. There is some susceptibility among cattle to the other two types. Humans are somewhat susceptible to the bovine type.

Symptoms of tuberculosis in cattle include a gradual loss of weight and condition, and a chronic cough when the lungs are involved. Lesions develop most frequently in the lungs, but may develop in nearly any organ. Death occurs in advanced cases. Frequently, animals do not show external symptoms until internal lesions are well developed and widespread.

There is no satisfactory treatment for tuberculosis in cattle. Infected animals are detected by a skin test. There is an eradication program by federal and state governments which has been underway since 1917. By 1940, the entire United States was declared a modified accredited area, meaning that less than 0.5 per cent of the cattle in each county were infected.

New animals introduced into a herd should be tuberculosis-free, and contact with other herds should be kept at a minimum. Since cattle may

react to the tuberculin test after contact with the avian type of tuberculosis, wild birds should be discouraged around barn areas and feed lots.

Although infection has been reduced to a low level, continued vigilance is necessary. Recently, there have been increased infection rates in some areas. All herds should be tested annually for tuberculosis.

Paratuberculosis (Johne's Disease). This disease is widespread throughout the United States, but does not affect many cattle. Symptoms are a persistent diarrhea which does not respond to any usual treatment. There is a rapid loss of weight, accompanied by a rough hair coat and a dry skin. Appetite is reduced, but usually in the later stages. Fever is not normally present. There is a test available for Johne's Disease, which should be used on all animals when infection is known or suspected in a herd. Diagnosis is based on isolation of the organism or positive reaction to the test. There is no satisfactory treatment, although vaccines have been attempted. Because of the chronic nature of the disease, it is frequently not recognized until in the advanced stages.

Prevention involves complete separation of healthy animals from infected ones and their excreta. Complete sanitation is important. The causative organism is not killed by usual concentrations of chlorine or lye solutions and special measures to destroy it are frequently necessary.

Trichomoniasis. This is a true venereal disease of cattle, spread by the act of mating. The organism *Trichomonas foetus* lives in the reproductive tract of the cow and in the sheath around the penis of the bull. Infection in the female results in interruption of pregnancy, in such early stages that usually no evidence of abortion is observed. Rather, delayed or irregular heat periods occur persisting over a period of several months before pregnancy is established. Considerable accumulation of pus in the uterus sometimes occurs. If this persists, the animal may not return to heat.

Diagnosis is based on the isolation and identification of the organism. Treatment in the female consists of a rest from reproduction for three to four months, during which time the infection usually clears up. Some cases of infection may require a longer period of rest.

In the male, special rather complicated treatments are available which offer some degree of success when administered by a competent person.

Tricomoniasis is prevented by inspecting, and withholding from use, bulls not known to be free from the disease. Matings between disease-free bulls and possibly infected females should be kept at a minimum.

Artificial insemination does not afford protection, since the trichomonads are not affected by usual semen processing techniques or by the antibiotics used in extenders. Bulls used in artificial insemination should be thoroughly checked before being placed in service.

Vibrio fetus. Another cause of abortions early in pregnancy is infection with the organism *Vibrio fetus.*

This organism resides in the reproductive tract of the female and in the male particularly in the prepuce Symptoms of the disease occur in cows and heifers which repeatedly return to heat for periods of from three to six months In some instances the infection may last up to a year The disease is transmitted at the time of mating Diagnosis is based upon the isolation and identification of the organism from the reproductive tract or from the stomach of an aborted fetus Accurate diagnosis is a fairly difficult process

Treatment for the female usually takes the form of a reproductive rest and breeding with artificial insemination since spontaneous re covery from the symptoms usually takes place A rather difficult treat ment is available for males Carefully controlled processing of the semen with the use of certain antibiotics seems to afford good control of the organism However there is still some question in regard to its total effectiveness

Preventing matings between disease free and possibly infected ani mals is important

Leptospirosis This is a disease which infects a wide range of animals including cattle and man There are several varieties of the organism which may be involved *Leptospira pomona occurs* most frequently in cattle Symptoms include abortion which may occur at any stage of pregnancy but most frequently during the final one third Weak or still born calves may result if they are carried to term

Reduction or stopping of milk production may occur The milk may become yellowish like colostrum or colored with blood The udder may show abnormalities The urine may become colored with blood The more severe cases may be accompanied by fever and lack of appetite which lasts for several days

The organism is shed in the urine and may be transmitted by anything which has been contaminated by infected urine Some individuals may shed the organisms for a long period after becoming free of the symptoms Definite diagnosis depends upon isolation and identification of the organism which is a difficult task. Tentative diagnosis may be made by a serological test Completely satisfactory treatments are not available although the use of certain antibiotics may reduce some of the symptoms.

Leptospirosis can be prevented by eliminating the contact of healthy animals with possible sources of infection These include rodents and other smaller animals which may be infected or transport the organism on their bodies Contact between herds should be avoided, including contact by streams flowing from one farm to another

Newly purchased animals should be checked by the serological test before introduction into the herd. If leptospirosis is diagnosed in a herd, or a neighboring herd vaccination for the disease may be recommended The vaccine currently available provides immunity for a limited time

up to six months, after which revaccination may be desirable. More research information is needed on this disease and the development of control measures.

Shipping fever. Disorders involving the respiratory system of cattle are almost universal in occurrence. Symptoms include an elevated temperature, chills, increased breathing rate, depression, loss of appetite, watery discharge from the nostrils and eyes, and a characteristic cough. Death may result directly from this "shipping fever," or from secondary causes brought on by the weakened condition.

The organism or organisms causing the disease are not known. It appears to be brought on by unusual stress placed on the animal, particularly in transporting it from place to place; hence the name. Areas such as stockyards, cattle cars and trucks, and show arenas, where many cattle move through, apparently become contaminated with shipping fever. Some recovered animals may be carriers of the disease. Young animals are frequently more susceptible than older ones.

There are no really satisfactory treatments or preventive measures. Administration of certain antibiotics to the sick animals, and other animals in the herd, frequently reduces the severity of some of the symptoms and helps control complications resulting from the infection.

Injections of certain bacterins or serum preparations have been used in attempts to control shipping fever. No clear-cut success has been indicated where careful tests have been made. The best preventive recommendations which can be made are the practice of good sanitation, prevention of contact between infected and healthy animals, and management of cattle in such a way that they are subjected to a minimum of stress.

Foot rot. This is a term used to describe non-specific infections of the feet of cattle. Symptoms are lameness and swelling of the affected leg above the hoof. There is frequently an open site of infection somewhere in the horny part of the hoof. It is treated by cleaning, including removal of dead tissue, and disinfecting the infected area. Bandaging to keep the area clean is usually recommended. Systemic treatment with antibiotics or sulfa drugs is sometimes helpful. In severe cases, amputation of part of the foot may be necessary.

Prevention involves the elimination of muddy or wet contaminated areas where cattle can stand or walk and pick up infection. Cattle should not be allowed to stand in manure-filled gutters. Trimming overgrown feet and eliminating other causes of breaking of hooves, which provide an opportunity for the infectious organism to enter, are helpful measures. Providing a shallow box filled with lime through which cattle are forced to walk may be helpful, but is less desirable than elimination of poorly drained areas and of other sources of infection.

Anthrax. This is a highly contagious disease of great virulence. It is

caused by the organism *Bacillus anthracis.* It results in symptoms of brain damage, staggering, difficult breathing, convulsive movements and death. Less acute forms of the disease involving swelling in various parts of the body. Lesions of the tongue or throat may occur.

Positive diagnosis is based on isolation of the organism. The organism is spread in many ways and is difficult to destroy. Thus complete and intensive sanitation measures are necessary when the disease is present. Certain antibiotics are fairly effective in treatment.

A high degree of protection may be obtained by vaccination. This is usually practiced in herds and areas where the disease may be a problem, rather than as a routine measure. Anthrax does not occur with very great frequency in this country.

Blackleg. Blackleg is known in most sections of the United States. It affects young cattle six to nineteen months old particularly. The organism involved is *Clostridium chauvoei.* Symptoms are high fever, the presence of swellings under the skin which are filled with gas, loss of appetite, stopping of rumination, rapid breathing, and depression. Death occurs in most cases in 12 to 36 hours.

Early treatment with antibiotics usually gives good results. Treatment in advanced stages is ineffective. Calves two to four months old should be vaccinated against blackleg. Immunity persists for nine to twelve months, and vaccination of individual animals may need to be repeated to get them over the susceptible period.

Pink eye. Pink eye, or *infectious keratitis,* occurs throughout the world. The organism *H. bovis* has been implicated in the disease, but speculation still exists as to its actual cause.

Symptoms are a swelling of the eyelid, which becomes red and congested. A watery discharge occurs in early stages, which later contains mucus and pus

In some cases, ulcers form on the eyeball, permanently blinding the cow. Temporary blindness frequently occurs. Pink eye may be transmitted from infected animals to healthy ones New animals introduced into a herd frequently bring in the infection.

Antiseptic eyewashes and sometimes certain antibiotics are helpful in certain individual cases, but a satisfactory treatment is not available. Treatment of symptoms, and keeping infected animals in a cool, dark place are recommended. Elimination of flies, which may spread the disease, and isolation of new animals or those which are suspected to have the disease for 60 days, will aid in controlling it.

Actinomycosis and actinobacillosis. Infection with the organism *actinomyces bovis* usually occurs in the bones of the upper or lower jaw and is frequently called "lumpy jaw." The symptoms of lumpy jaw are a large swelling on the bone involved, usually accompanied by soreness. *Actinobacillus lignieresi* bacteria infect the soft tissues of the head

and neck. The latter disease is responsive to treatment. Antibiotics, sulfonamides, iodides, and surgery are used. Similar treatments are used on actinomycosis, but recovery is less frequent.

Good sanitary measures and the separation of diseased animals are the best prevention.

Listeriosis (sometimes called listerellosis) is caused by *Listeria monocytogenes*. Infection is sporadic and usually limited to a few animals, but as much as a fifth of some herds may be afflicted. The first symptoms are feed refusal and restlessness. Temperature rises are frequent. There are signs of central nervous system dysfunction. Animals may walk in circles with apparent blindness. Progressive inco-ordination, paralysis and death may follow. Some animals gradually improve and eventually recover.

Successful treatment is not available, nor are preventive measures, except for good sanitation procedures.

Foot and mouth disease. This is one of the most feared of animals diseases. Man does not appear susceptible to it. Fortunately, it is not known to exist in the United States at this time. There have been, however, a number of outbreaks in the past which have required severe measures to eliminate.

Foot and mouth disease is responsible for the prohibition of imports to the United States of live animals or animal products from many countries, unless they are steam cooked or otherwise specially processed.

A tiny virus is the cause of the disease. Symptoms are blisters or vesicles on the membranes of the mouth and tongue and on the feet. These may also occur on the udders of cows.

Slaughter of all infected and exposed animals with burning or deep burial is the method of elimination used in this country. Vaccination is used to some extent with limited success in other areas. Symptoms of foot and mouth disease resemble those of vesicular stomatitis, which also affects cattle. Any suspected cases should be reported immediately to a veterinarian for diagnosis.

Vesicular stomatitis. This is a virus-caused disease resulting in vesicles or blisters in the mouth. In appearance, it is similar to foot and mouth disease, and laboratory tests are necessary to differentiate between them. The disease is spread most frequently by direct contact. Treatment is not effective, but animals normally recover from uncomplicated cases of infection. Isolation and rigid sanitary measures are indicated. Because prompt diagnosis is important to differentiate this disease from foot and mouth disease, any suspicious condition should be reported immediately to a veterinarian.

Muscosal diseases. These virus-caused diseases are of fairly recent diagnosis. Four or more distinct groups are recognized. They are characterized by irritation of the mucous membranes of the respiratory sys-

tem and the digestive tract. Diarrhea is a frequent symptom and it is sometimes referred to as *virus diarrhea.* When the respiratory system is involved, discharges and other usual symptoms of respiratory infection occur. Some of the same viruses may be involved in the shipping fever syndrome.

Little detailed information is available on the diseases. Specific control measures have not been prescribed. Good sanitation procedures and treatment of symptoms are in order.

Anaplasmosis. Parasitic invasion of the red blood cells occurs in this disease. A protozoa, *Anaplasma marginale,* is the causative organism. Symptoms, except for the fever which may occur early in the infection, result from the destruction of red blood cells. Loss of weight, increased rate of breathing and heart beat, and paleness of mucous membranes are usually observed. Animals, particularly younger cattle, may have the disease in rather mild form. It also may be very acute, with death occurring in 24 hours after the appearance of symptoms. Many variations between these extremes occur.

The exact mode of transmission of the disease is not well uoderstood, although several species of ticks have been implicated.

Treatment with certain antibiotics seems to reduce the activity of the parasites. Time is needed, however, to replenish the supply of red blood cells. Blood transfusions are helpful in this regard.

Prevention involves control of ticks, which may serve as intermediate hosts or carriers, aod the elimination of animals which may be carriers of the disease.

PARASITES OF CATTLE

A number of parasites infect dairy cattle and cause considerable losses. As with diseases, prevention is the most economical method of control. Healthy, well-fed animals are best equipped to combat parasites.

A number of parasites are shed in the feces of cattle and are consumed by grazing animals. Paddocks and intensively grazed pastures can become heavily contaminated and a source of danger, particularly to young animals. In areas where parasites are particularly troublesome, each group of calves and young cattle should be provided paddock and grazing areas which have not been recently contaminated by older cattle or sheep.

Few cattle are entirely free of internal parasites in some form. However, most well-managed and well-fed animals apparently do not suffer seriously from them. A number of chemicals are available for combating parasites in cattle. Chemicals should be used carefully for milking cows, since many of them appear in milk. No milk contaminated with medica-

tion should be allowed to enter the supply used for human consumption.

Diagnosis of parasites of the digestive tract of cattle is usually made by isolation of eggs or other evidence from the feces.

Bovine coccidiosis. This is a common parasitic infection of young calves. Symptoms are diarrhea, general weakness, rough hair coat, and retarded growth. A number of species of protozoa are responsible. It is among the most important parasitic problems in cattle, being responsible for a considerable portion of calf scours.

Calves between three weeks and six months of age are most frequently affected, but it may attack animals of all ages. The coccidia are ingested with feed contaminated by the feces of infected animals. When in the proper stage of development, they enter the cells lining the intestine, where they go through several stages of development before the oocyst, which is excreted, is finally produced. It is during this time that feces which may contain blood, mucous strands, and even pieces of intestinal lining are excreted. Treatment of badly infected animals is usually not effective, although sulfa drugs may be of benefit.

Roundworms in cattle. A large number of different roundworms may be found in the stomach and intestine of cattle. Frequently, a number of species may be found in one animal. Most of the species have a similar type of life cycle. Eggs are excreted in the feces of infected animals. Larvae develop from the eggs and after characteristic development are consumed by grazing cattle. (The larvae of some roundworms, however, can penetrate the skin of cattle and eventually work their way to the digestive tract.) In the digestive tract, the larvae mature and attach themselves to, or bore into, the lining of the tract. The mature female produces eggs and the cycle is repeated.

Roundworms are damaging to cattle, considering the nutrients which they steal from them and the damage they do to the intestinal or stomach wall, which may be very severe.

Symptoms of roundworm infection are diarrhea, anemia, general weakness, rough hair coat, retarded growth or weight loss and, in severe cases, death. Diagnosis is by isolation of eggs from the feces. In some instances, this is complicated by the fact that eggs may not be produced for a considerable period after symptoms occur.

Prevention of infestation is important. When outside the body, the larvae require moist conditions. Well-drained pastures, elimination of mudholes, and the practice of fencing cattle away from ponds, streams, and marshy areas is helpful. The rotating of pastures, with a considerable period between grazings, allows many of the larvae to die before they can be consumed. It is particularly important to limit the grazing of young calves to uncontaminated areas. New animals which may have roundworms should be kept in isolation and examined for parasites before being admitted to the herd.

Treatment may be made with a number of drugs, of which phenothiazine is the most commonly used When administered at recommended levels, it is effective against a number of species If a species is present which is not controlled by phenothiazine, the recommendations of a veterinarian should be followed Phenothiazine cannot be used to treat milking cows while the milk is used for human consumption, since the drug appears in the milk.

Tapeworms and bladderworms Several species of tapeworms and bladderworms infect cattle Tapeworms may be several inches long and up to ¾ inch wide They attach themselves to the wall of the intestine, where they obtain nutrients Segments of the worm and eggs are discharged in the feces Tapeworms can be controlled by the administration of proper drugs to the animal

An intermediate host, the beetle mite, is necessary for the life cycle of the tapeworms which are most important in cattle The effect of tapeworms on cattle is not well understood, since they rarely occur as the only parasite

Bladderworms in cattle occur when they eat the eggs of tapeworms excreted in the feces of dogs or man These worms bore into various tissues, where they form a cyst One species locates in the brain, with serious consequences With this exception it is generally believed that the most serious effect of bladderworms is the loss of meat contaminated by them

Bladderworms are controlled by preventing the consumption of eggs by cattle Keeping dogs free of parasites through medication and the destruction of infected meat, along with good general sanitation, is usually recommended

Lung worms One type of worm parasite enters the lungs of cattle, where it causes pneumonia like symptoms which at times result in death This parasite is most serious in the Southeastern United States and on the Pacific Coast Larvae are coughed up by the infected animal, swallowed, and passed out in the feces After a period of development, if the larvae are consumed by another animal, they get to the lungs and set up a new infection An animal with only a slight infection may be dangerous because of the number of parasites excreted.

Liver flukes There are several species of liver flukes which attack cattle While the greatest economic loss is in condemned livers at slaughter time, heavy infection can result in reduced production of the host. Liver flukes have an interesting life cycle. They lay eggs in the bile ducts of the liver The eggs pass out of the host with the feces Hatching takes place in water and the larva swims about until it finds a suitable snail, into which it bores Several varieties of snails are involved, some specific for the different varieties of flukes

Inside the snail, the fluke undergoes a number of changes before it

leaves and becomes attached to vegetation near the surface of the water. After being eaten by cattle or sheep, the flukes work their way through the intestinal wall. Eventually they reach the liver, which they penetrate, finally entering the bile ducts and maturing in about three months. The damage caused by these organisms in the liver can be very extensive.

Control of liver flukes is difficult and complex. Keeping cattle away from pools of water and from forage which has been grown in stagnant water is the best management procedure. Some measures are available to eradicate the intermediate hosts, the snails, but these are difficult and costly.

Mange or Barn Itch. There are several parasites which attack the skin of cattle. Several varieties of mites burrow into the skin, causing irritation and scabbing. They are most frequently found in areas of thin skin and little hair, as on the inside of the rear legs. The damage is the irritation to the animal and the danger of infection in the lesions. Treatment involves the use of toxaphene, lindane, or other insecticides. One type of mite produces nodules in the skin in the area of the shoulders or neck. This organism is difficult to treat. Usually mite infestations are worse in the winter period and when animals are confined. Mites are spread by direct contact and, probably, by currycombs and other equipment. Some of the mites are transferable to humans. If mite infestation is suspected, a veterinarian should be consulted for diagnosis and recommended treatment.

Lice. Cattle are susceptible to blood-sucking lice of several different species. They cause itching, irritation, and poor condition of animals. Infestations usually are most pronounced during the winter months. Control of lice is accomplished with a number of insecticides. DDT, Methoxychlor, BHC, and others are effective. Care should be taken to use only materials approved for lactating cows if the milk is used for human consumption.

Cattle grubs. Heel flies or warble-flies are a problem in all parts of the United States. They lay eggs on hairs on the lower legs of cattle. The larvae hatch here and penetrate the skin, then make their way through the tissues to the back of the animal. They cut through the skin for a source of air. The grub matures in this spot, creating a bump in the skin. The lumps usually appear during the winter months. The larvae matures and leaves the animal in early spring.

Heel flies are damaging in many ways. Hides and meat are reduced in value. There is much irritation caused by the grubs, which results in reduced feed consumption and production. Cattle have a great fear of the flies and often become very excited and run about in a characteristic manner during the egg-laying season.

Control of this pest is usually aimed at destroying the grubs when they are in the host. Chemicals are available which may be fed or sprayed

on cattle for absorption through the skin. These are distributed throughout the animal's system and destroy the grubs before they reach its back. These treatments are not used on lactating cows or on animals soon to be sold for slaughter. For cattle in these categories, insecticides are available which, when applied to the back, destroy the grub before it emerges. With the availability of the systemic treatment, it is hoped that the occurrence of this pest may be greatly reduced.

Flies. Control of flies is a problem in all dairy production units. Health and comfort of the cattle are involved, as well as compliance with sanitary requirements for producing high-quality milk. Health and comfort of workers are also a factor. Flies affect dairy cattle by biting and blood-sucking, and by carrying diseases. Major losses in production are suffered from the irritation and blood-sucking activities of flies.

Control of flies starts with the elimination of growing sites for the larvae. These include manure and decaying organic matter from any source. Frequent removal and spreading of manure is essential. Drainage or filling of wet areas is helpful.

Maintaining a high degree of cleanliness, as indicated above, will greatly reduce the fly population. However, some direct control measures are usually necessary. There are a number of insecticides which are effective against flies. These include DDT, Methoxychlor, Lindane, Chlordane, organic phosphates, Malathion, organic thiocyanates, pyrethrins, and others. They may be used as sprays, dusts, baits, or fogs. Pyrethrins are the safest, from the point of view of danger to animals or man. Many of the insecticides can be used only in restricted ways around cattle because of the possibility of contamination of milk. Organic phosphates and some other insecticides are dangerous to all animals, including man. Flies may build up a resistance to some insecticides, such as DDT, which may lose its effectiveness in a given area. This requires the use of a variety of insecticides. Recommendations of local authorities should be followed in developing the most effective, approved fly-control program

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Cole, H H, and J M Boda, "Continued Progress Toward Controlling Bloat. A Review," *Journal of Dairy Science*, 43·1585, 1960

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11 Dairy Cattle Housing

EFFECTIVE housing for dairy cattle should be designed to meet requirements for health and comfort of the animals, convenience and comfort of the operator, efficiency of labor and materials handling, and compliance with applicable health regulations.

Health and Comfort of Animals

Dairy animals have simple requirements in regard to housing. Protection from storms and drafts or high winds in cold weather is adequate. Cattle have a high degree of resistance to cold and thrive in very low temperatures if they are kept dry and free from exposure to direct wind currents. Shade is important in hot weather. Clean, dry, and sanitary surroundings are necessary for disease control and for the production of quality milk.

Freedom of movement, as provided by loose housing or stalls of adequate size, is important in preventing udder and leg injuries.

Convenience and Labor Efficiency

Dairy cattle housing should be so designed that the operator can feed, milk, and provide care for the herd with a minimum expenditure of time, travel, and physical labor. Maintaining an economical operation requires the maximum efficient use of automation in the handling of feed and manure, as well as in the milking operation. Labor costs must be kept as low as possible if an adequate financial return is to be provided. Ready and convenient access to the animals for treatment and management procedures is needed.

Health Authority Regulations

In all localities, health authorities have developed regulations concerning the housing of the milking herd. These regulations are designed to assure the public of high-quality, clean milk at all times. The accomplishments of these regulations, and the excellent sanitary operation of

on cattle for absorption through the skin. These are distributed throughout the animal's system and destroy the grubs before they reach its back. These treatments are not used on lactating cows or on animals soon to be sold for slaughter. For cattle in these categories, insecticides are available which, when applied to the back, destroy the grub before it emerges. With the availability of the systemic treatment, it is hoped that the occurrence of this pest may be greatly reduced.

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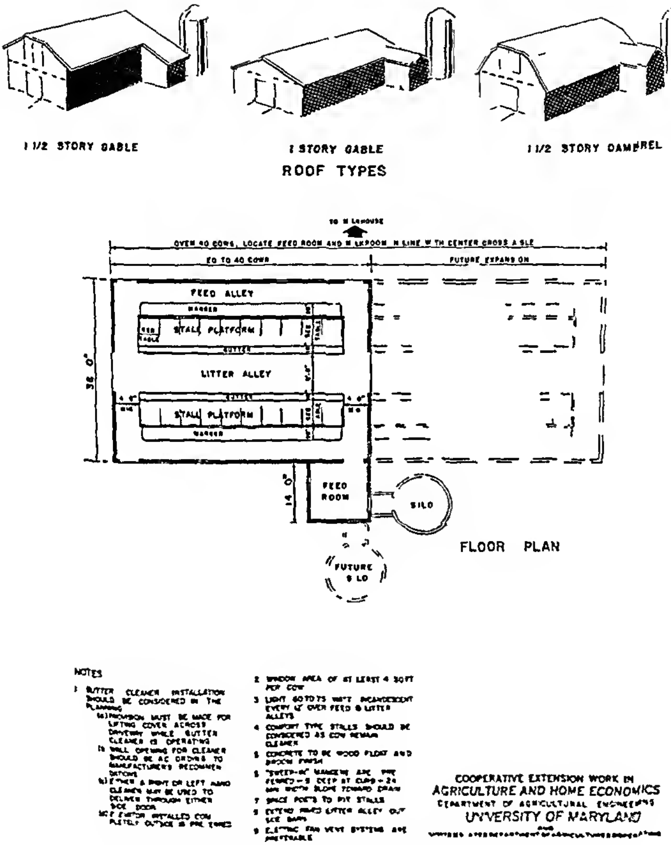


Figure 11 Layout and some suggested specifications for a stanchion type barn

the entire dairy industry, are demonstrated by the confidence of the public in the milk supply throughout this country.

Health-authority regulations cover space available to each animal, lighting, ventilation, building materials, manure disposal, health of the cows and handlers, drainage, and other factors. They may be established by municipal, county, or state governments. Recently the United States Public Health Service, in co-operation with other agencies, has established suggested minimum standards for the production of milk. These are presented as two sets of suggested standards, one for the production of milk for fluid consumption and one for milk for manufacturing purposes.

A thorough study should be made of the health regulations pertaining to the market or markets where milk is expected to be sold before new construction or remodeling of housing for dairy cattle is undertaken.

TYPES OF HOUSING

Dairy cattle may be successfully housed under a wide variety of conditions, ranging from close confinement to little restriction except at milking time. Housing for cattle is commonly described as *conventional* (or *stanchion*) *barns* and *loose housing*. Stanchion barns refer to housing as shown in Figure 11.1, in which the cows are confined close together on a platform and secured at the neck by stanchions. Feed is provided at the stanchions and the cows are milked there.

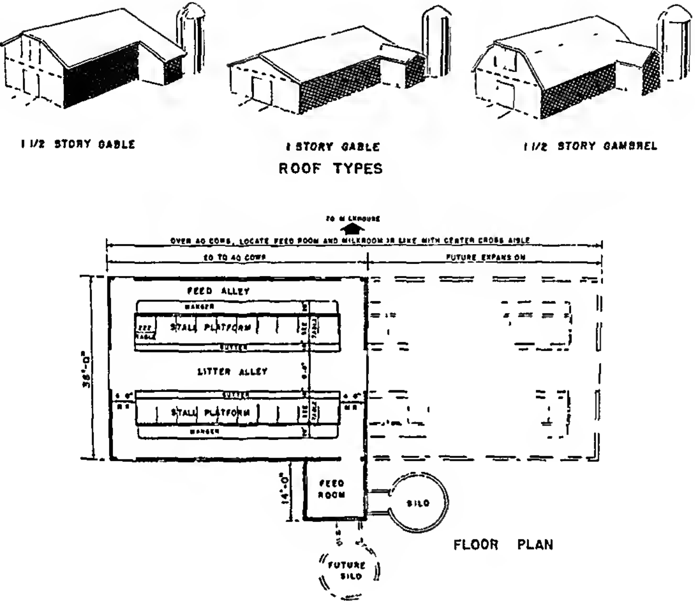
Loose housing, as shown in Figures 11.2 and 11.3, is arranged so that the animals can roam at will within the housing area. Forage is usually provided in bunks on a more or less free-choice basis, depending upon the details of the feeding program. Milking is done in a room designed specifically for this purpose called a *milking parlor*. Concentrates are usually fed in the milking parlor, but other arrangements may be made.

In practice, all gradations between the two types of housing are employed. The specific design depends upon many factors associated with individual farms.

Modern equipment and the need for labor efficiency have established a definite trend toward the use of loose housing and milking parlors. Following are some of the details which should be considered in different types of housing.

Loose Housing

Loose housing is defined as a system in which animals usually are closely confined only at milking time or for medical treatment. Herds are handled on a group basis except for these func[illegible] sick



NOTES

1 GUTTER CLEANER INSTALLATION SHOULD BE CONSIDERED IN THE PLANNING
   (a) PROVISION MUST BE MADE FOR LIFTING COVER ACROSS DRIVEWAY WHILE GUTTER CLEANER IS OPERATING
   (b) WALL OPENING FOR CLEANER SHOULD BE ACCORDING TO MANUFACTURER'S RECOMMENDATIONS
   (c) EITHER A RIGHT OR LEFT HAND CLEANER MAY BE USED TO DELIVER THROUGH EITHER SIDE DOOR
   (d) ELEVATOR INSTALLED COMPLETELY OUTSIDE IS PREFERRED

2 WINDOW AREA OF AT LEAST 4 SQ FT PER COW

3 LIGHT 60 TO 75 WATT INCANDESCENT EVERY 12' OVER FEED & LITTER ALLEYS

4 COMFORT TYPE STALLS SHOULD BE CONSIDERED AS COW REMAIN CLEANER

5 CONCRETE TO BE WOOD FLOAT AND BROOM FINISH

6 "SWEEP-IN" MANGERS ARE PREFERRED – 8" DEEP AT CURB – 24" MIN WIDTH SLOPE TOWARD DRAIN

7 SPACE POSTS TO FIT STALLS

8 EXTEND PAVED LITTER ALLEY OUTSIDE BARN

9 ELECTRIC FAN VENT SYSTEMS ARE PREFERABLE

COOPERATIVE EXTENSION WORK IN
AGRICULTURE AND HOME ECONOMICS
DEPARTMENT OF AGRICULTURAL ENGINEERING
UNIVERSITY OF MARYLAND
AND
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING

Figure 11 1 Layout and some suggested specifications for a stanchion type barn

The milking herd. For the milking herd, a typical loose-housing arrangement consists of a feeding area, a bedded area, a paved area, a holding area, and space to confine cows at calving time or for temporary illness and treatment, and so forth. Provision for storage of feed and bedding and manure removal are important considerations. Figures 11.2 and 11.3 present typical and satisfactory layouts for loose housing. Many variations of these designs provide practical housing. Specific requirements will vary with the locality, but the following space recommendations will apply in most areas.

A bedded area of approximately 60 square feet per cow is suggested. The bedded area provides a place for the cattle to rest. It should be closed on the north or windward side and open on the south. Bedding is usually allowed to accumulate during an entire winter period. Additional bedding is added as needed. Fermentation in the bedding pack provides a warm place for the cattle to lie. The bedded area need not be paved. No feeding, watering, or holding of cows should be carried out in the bedded area, and animal traffic should be held to a minimum to preserve a satisfactory condition of the bedding.

The paved area, including feeding space, should be approximately 100 square feet per cow. The paved area provides space for the cows to be in the open and is the area where hay and silage are fed. It should be designed so that it can be cleaned daily by scraping with a tractor and blade. Paving is important in this area to maintain good sanitation and cleanliness as well as to control foot rot and other problems which occur under muddy conditions. Feeding space, in length of bunks for hay and silage offered free-choice, should be 12 to 18 inches per cow. When forage is offered only at limited times each day, 24 to 30 inches of bunk space should be provided for each cow. It may be desirable to have roofed feed bunks in some circumstance. Self-feeding from horizontal silos may be done by allowing 6 inches per cow. Figures 11.4 and 11.5 contain diagrams of several useful feeding arrangements.

The holding area should provide approximately 15 square feet per cow. Cows are confined in the holding area in preparation for milking. From the holding area cows go to the milking parlor and return to the paved area.

Waterers should be provided on the basis of a minimum of one cup per 25 cows, and should be located near the feeding area. A minimum area of 10 to 12 feet in diameter should be paved around the waterers. All paved areas should have a minimum slope of ¼ inch per foot to provide proper drainage.

Feed should be stored as close to where it is to be consumed as possible. Full use should be made of silo unloaders and mechanical movement of feed, where the herd size and quantity of feed used justifies it.

Box stalls for use as maternity pens and for handling *sick* cows

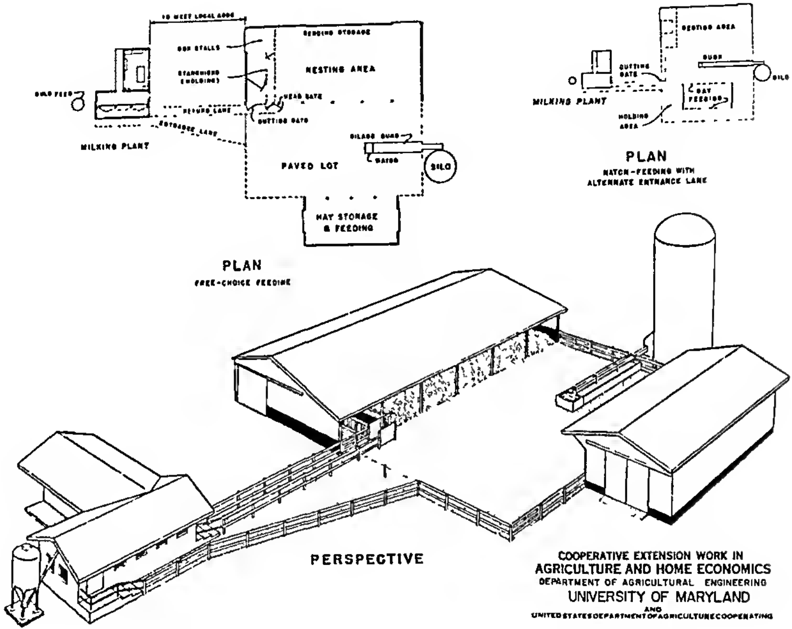


Figure 11.2. Layout of a well-designed loose housing arrangement for dairy cattle.

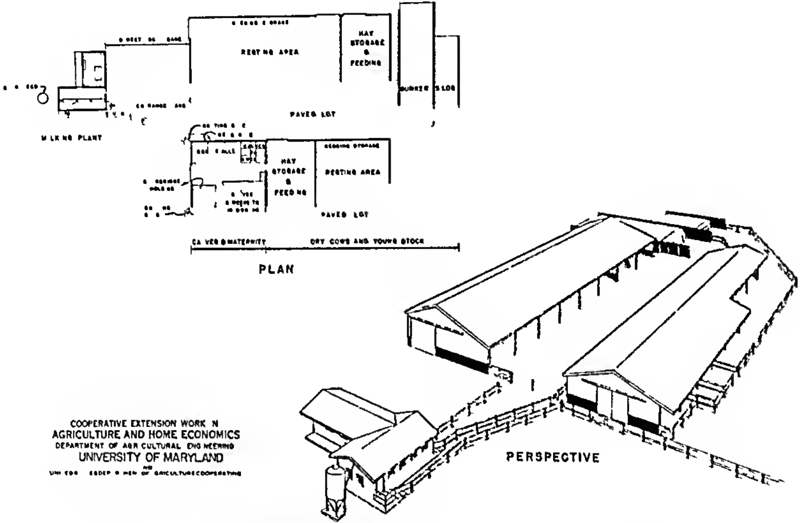


Figure 11.3 Layout of a loose housing arrangement for dairy cattle including provision for young animals.

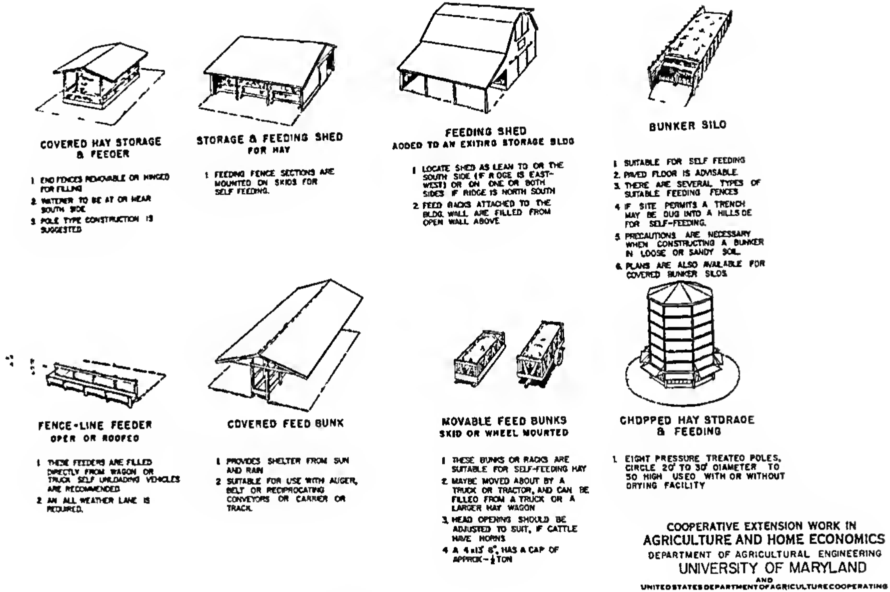


Figure 11 4 Outlines of several practical self-feeding units for dairy cattle

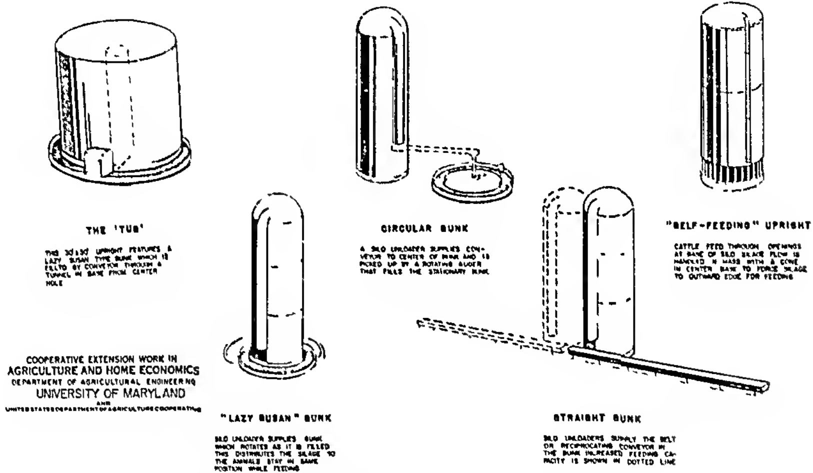


Figure 11.5. Arrangements for efficient feeding of silage from an upright silo.

should be available in a convenient location at the rate of approximately one for each 15 animals. In addition, sufficient stanchions should be provided to allow for breeding, examination and treatment, blood-testing, and clipping of cows. The number of stanchions should equal about 10 per cent of the herd up to ten stanchions. Location of a cutting gate, in the alley leading away from the milking parlor, which can be used to direct animals to the isolation and treatment area, is very helpful. A squeeze chute in the same area is useful in confining animals for treatment. Where large herds are handled in loose housing, it is desirable to divide them into groups. Division may be on the basis of size, level of production, or other factors. Variations in feeding and management for different segments of the herd are possible when the herd is divided. With attention to design and location of feed bunks and so forth, the housing arrangements shown in Figures 11.2 and 11.3 may be divided by a simple arrangement of fences and gates. The optimum size of groups varies with the management situation. In most instances there is little to be gained in handling groups smaller than 30 or 40 cows. Groups larger than 100 head make any sort of individual management difficult.

A "pie-shaped" design for loose housing for cows is sometimes recommended in warmer climates. The "pieces of pie" represent corrals which are arranged around a central milking facility. Forage is stored and fed at the outer edge of the corrals. Cows are usually handled in groups of 20 to 30. A minimum of shelter is provided, but shaded areas are included in this type of housing. Provision for caring for calves and animals needing treatment is made near the milking area. The circle of corrals can be nearly complete, providing an access road is provided to the milking parlor.

Frequently it is desired to remodel existing buildings to accommodate cows in a loose housing setup. Depending upon the design of the buildings available, they may be modified to provide various combinations of the feed and bedding storage, bedded area, or feeding area. Figure 11.6 shows how existing buildings may be so used.

Providing for calves, heifers, and dry cows is an important part of a loose housing arrangement. Young animals requiring intensive care should be located where they can be provided for with a minimum of travel. Figure 11.3 presents a system in which these animals may be cared for efficiently. More detail of the calf housing is shown in Figure 11.7. This type of building may be designed in a size to fit the requirements of any given herd.

Individual calf pens of approximately 24 square feet are satisfactory for calves up to 8 weeks of age. The use of portable pens for calves is discussed in Chapter 6. Group pens (providing approximately 35 square feet per animal), with access to outside lots, are desirable for older

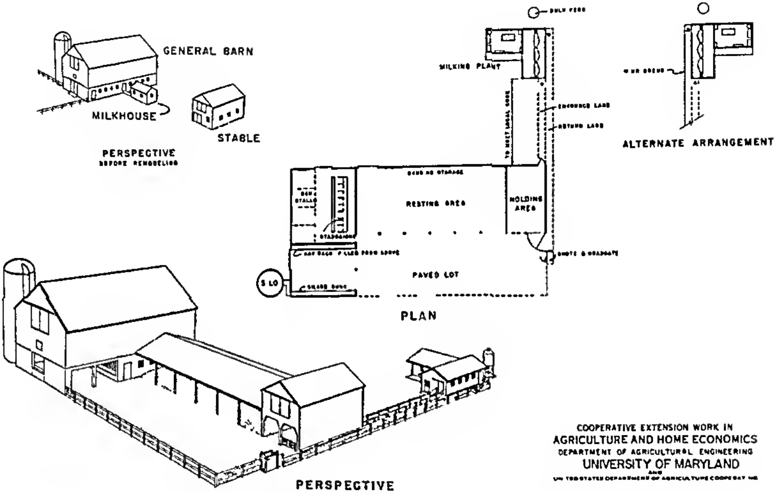


Figure 11 6 An example of how existing stanchion type barns may be remodeled for loose housing

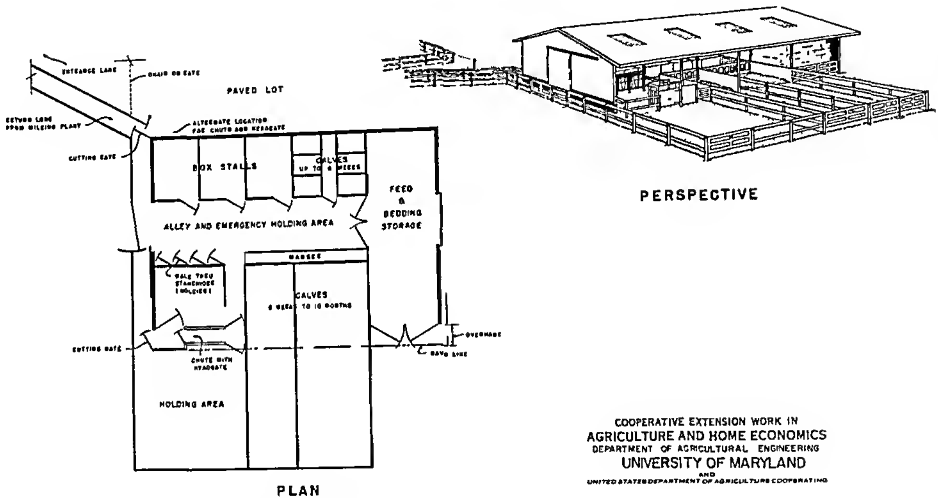


Figure 11.7. Layout of a building designed to house dairy calves and cows at calving, and to confine animals during illness or for treatment.

calves Heifers from 6 to 8 months of age to calving need a minimum of housing protection, provided feeding space is adequate and quarters are clean and dry.

Stanchion Type Barns

Milking cows can be efficiently handled in well-designed stanchion barns. Figure 11.1 contains a barn layout which provides for adequate space and efficient use of labor. The design in Figure 11.1 provides for 20-cow units which may be easily expanded with increasing herd size, if the buildings are well located. Provision is made for a minimum amount of travel in feeding and caring for the herd.

Adequate size of stalls is important in designing a stanchion barn. Udder and leg injuries occur with increasing frequency when stalls are too narrow or short. The dimensions listed in Table 11.1 will provide stalls of recommended size. So-called "comfort stalls" of somewhat larger size, and supplying more freedom for the cow, are sometimes used.

TABLE 11.1. RECOMMENDED DIMENSIONS FOR STALLS FOR DAIRY COWS OF VARIOUS SIZES.

Weight of Cow (lbs)	Heart Girth of Cow (inches)	Stanchion Stalls	
		Width	Length
800	65	3'6"	4'8"
1000	70½	3'9"	5'0"
1200	75	4'0"	5'4"
1400	79½	4'3"	5'8"
1600	84	4'6"	6'0"

Full advantage should be taken of labor-saving equipment wherever possible in a stanchion barn. Gutter cleaners, pipeline milkers, and mechanical handling of forage and grain should be considered.

Box stalls for maternity use and for handling sick cows are needed in the same ratio as in loose housing. They may be provided in a building similar to that in Figure 11 7.

Providing for calves, heifers, and dry cows. The requirements for housing calves are the same as for a loose housing setup. Group handling of heifers is desirable, whenever possible, to provide for labor efficiency. Figure 11 7 includes a layout of quarters which may be used for heifers and dry cows equally as well with a stanchion barn. Dry cows may be handled with the regular herd or in a group, as provided for in a loose housing setup.

COMPARISON OF LOOSE HOUSING AND STANCHION BARNS

Many arguments are heard on the merits of loose housing versus stanchion barns. More important than the characteristics of either are the feeding and management practices followed. Experiments have indicated that, with proper attention and management, similar milk production may be achieved with either type of housing. Animals may be displayed to greater advantage in a stanchion barn. There is a somewhat smaller requirement for bedding, and animals are under more frequent observation in some instances. Labor efficiency is frequently greater in loose housing when it is well designed.

There may be less opportunity for udder and leg injury in loose housing, but again there is considerable variation among different herds and management situations.

Costs

It is difficult to provide accurate estimates of costs involved in housing for dairy cattle. The value of materials and labor for buildings varies tremendously even over relatively short distances. Loose-housing setups generally are appreciably cheaper to construct than stanchion barns. Pole-type structures, which are among the cheapest buildings to construct, are particularly adapted to loose housing.

These can frequently be built for $1.30 to $1.75 per square foot of area. An advantage of structures which are used in loose housing is that they can be adapted with little expense or alteration for other agricultural enterprises.

In most areas, a minimum investment of $450 to $500 per cow is required to provide housing and milking facilities. If equipment and buildings of more than average cost are used, the investment will be appreciably higher. The milking parlor is a major item of expense in loose-housing setups. Where large herds are kept, the cost per cow of a milking parlor is reduced by using it more intensively. There is no reason why a milking parlor cannot be used nearly 24 hours each day in a large herd, if labor can be arranged.

MILKING FACILITIES

Milking Plants

The milking parlor or milking plant has developed as the result of attempts to improve labor efficiency and working conditions surrounding the milking operation. By bringing cows to the milker and arranging

them at a convenient height for comfortable work, a great deal of travel, carrying of milk, and tiresome stooping and rising have been eliminated. The smaller area used more intensely also makes the maintenance of proper sanitary conditions for milking easier and more economical. Milk is normally moved directly from the milking claw through a pipeline to the cooling tank. Weighing or measuring the milk from each cow may be accomplished by a number of devices which fit into the line.

Loose-housing situations lend themselves particularly well to the use of milking plants. Figures 11.8 and 11.9 present layouts of two general types of milking plants. Both of these may be constructed in different capacities to allow for herds of varying size. The "in line" plant shown in Figure 11.8 may be modified by increasing the number of stalls, or by placing stalls on both sides of the pit or in a U-shaped design. In this type of parlor one man can effectively handle three stalls and milking machines. Attempting to use more than three units per man usually results in undesirable milking practices.

The "herringbone" milking plant shown in Figure 11.9 provides a situation where the udders of the cows are very close together and travel by the operator is minimized. This type of milking plant has a narrow operator's pit, and milker units are used first on one side, then on the other. Research has indicated that the most efficient size herringbone milking plant is one which provides a "double four" unit for each operator. Only a very skilled operator can handle larger numbers. The herringbone system is a fairly recent development in this country. It provides for rapid milking of a herd. However, since each animal comes under less observation than in other systems, additional care must be taken to provide adequate management supervision of the herd.

The use of milking parlors is not limited to loose housing. Some herds housed and fed in stanchion barns are milked efficiently in milking parlors.

Feeding concentrates in the milking parlor. It is a usual practice to feed the concentrate portion of the ration to cows while they are being milked. In loose-housing arrangements, this is frequently the only opportunity provided for individual feeding. Well-designed equipment is available for mechanical handling and metering the selected amounts for each cow. There are some management problems with this operation. High-producing cows often do not have time to eat as much grain as needed while they are being milked. In some operations, where limited grain is fed, the cow may consume it all before she has been milked and become difficult to handle as she searches for more feed. Either situation can disrupt the efficiency of the milking operation. There are not easy and economical answers to these problems. Operators of some large herds provide areas where cows may be fed concentrates individually, away from the milking parlor. These bave been found quite satisfactory

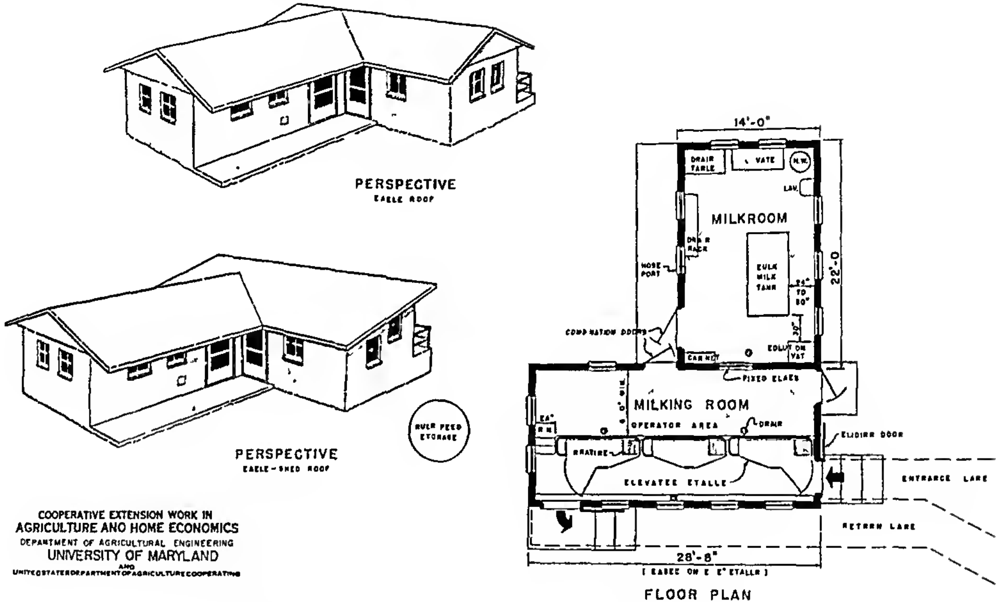
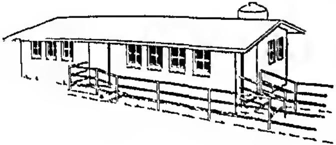
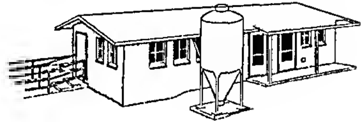


Figure 11 8. A layout of an "in line" milking parlor and adjacent milk room

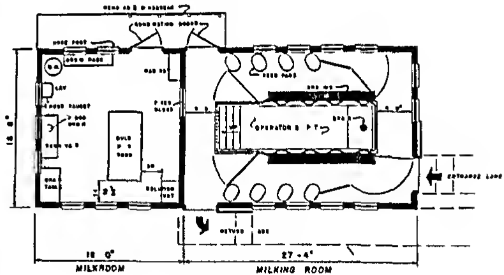


VIEW OF COW ENTRANCE & RETURN LANES

PERSPECTIVES



VIEW OF FEED BIN & FRONT ENTRANCE



FLOOR PLAN

COOPERATIVE EXTENSION WORK IN
AGRICULTURE AND HOME ECONOMICS
DEPARTMENT OF AGRICULTURAL ENGINEERING
UNIVERSITY OF MARYLAND

Figure 119 A herringbone milking parlor and adjacent milk room

where the labor aspects can be handled efficiently. After a short period of training, cows adapt readily to milking without being fed grain at the same time.

Pipeline Milking in Stanchion Barns

Pipeline milking systems, which conduct the milk from cows milked in stanchions directly to cooling and storage, are frequently used. They greatly reduce the carrying of milk when bucket-type milkers are used. In this system, milk is usually moved under vacuum. The system is satisfactory when the line is constructed so that there is a minimum of agitation which may lead to the development of undesirable "oxidized" flavors in the milk. The development of techniques for cleaning pipelines in place, with dismantling only at infrequent intervals, has greatly aided in their acceptance. In areas where they are acceptable to the health authorities, "dumping station" pipelines are well adapted. In this system, milk is moved from a portable dumping station behind the cows, through a flexible plastic pipeline to cooling and storage tanks.

Milk Houses

Space must be provided for the cooling and storage of milk on the farm, and a work area is needed for the cleaning and storage of milking equipment. Locating these facilities close to the milking area is important to maintain labor efficiency. Regulations provided by health authorities usually are quite specific in regard to location, drainage, building materials, and other details of milk houses. The regulations should be consulted in all cases before construction or remodeling is undertaken. Figures 11.8, 11.9, and 11.10 show sample layouts of milk houses which may be modified to conform to regulations existing in most areas. Bulk tanks for cooling and storage are included in these designs, since there is a rapid trend toward their use. On farms where cans are used for cooling and storage, appropriate changes should be made in the layout of the milk house to allow efficient handling of the cans.

General Considerations in Locating and Developing Housing for Dairy Cattle

Several factors should be reviewed before construction or remodeling of dairy cattle housing is undertaken.

Proper drainage at the site of construction is important. It must be able to accommodate surface water, and also the large volume of water used in the cleaning and sanitation of modern installations. In areas where sewage lines or other ready-disposal systems are not available,

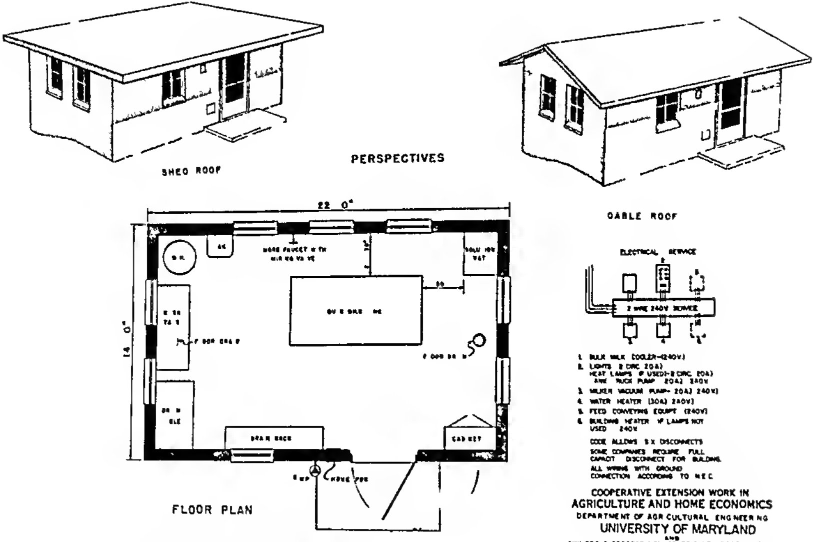


Figure 11.10 Layout of a milk house built as a separate unit

the use of "lagoons" or ponds, where waste water is stored while bacteria ferment the organic material present, should be considered.

Ready access by a road adequate to handle heavy-bulk tank trucks and other trucks bringing in supplies on all the days of the year is essential.

Any design of dairy cattle housing should be adapted to easy expansion in case there is need for a larger herd. Present trends are strongly in this direction, and they will probably continue. Using buildings which may be adapted to other enterprises with a minimum of cost is good planning. Rapidly changing conditions in agriculture make it important for an operation to keep opportunities open for different businesses.

There must be adequate facilities for the efficient removal and disposal of manure. This becomes an increasing problem as herd size increases and there may not be suitable land available to spread the manure the entire year. In some areas, manure is dried, sacked, and sold for home garden use.

Outward appearance of facilities used for dairy-cattle housing is a major consideration. Neat, clean buildings and grounds, designed to leave a pleasing impression to all observers, are important. A desirable impression on the general public is important in presenting the dairy industry to them. Greater pride of accomplishment, better morale, and a more efficient operation are the result of neat and pleasant surroundings.

Storage for Feed and Bedding

In most areas, storage facilities are needed for forages during at least part of the year. The most efficient facilities for this vary with the local climate and the length of the storage period, the type of forage to be stored, and regulations in effect in the local market regarding feeding and feed storage Total storage requirements depend on the feeding program followed. A cow eating 35 pounds of hay per day will consume just over one-half ton of hay every 30 days. Silage may replace hay at the rate of three pounds of silage to one pound of hay. The following is approximately the space required to store common forages and bedding:

Baled hay, 200 cu. ft. per ton; chopped hay, 250 cu. ft. per ton; silage (horizontal silo), 50 cu. ft. per ton, (upright silo), 40 cu. ft. per ton; baled straw, 250 cu. ft. per ton. Sawdust and baled shavings require approximately the same space as baled straw. Loose shavings require more space.

In loose housing, forages should be stored as closely as possible to the feed racks. Examples of efficient storage and feeding arrangements are shown in Figure 11.4. A number of schemes for automatic handling

or self-feeding of silage are included in Figure 11.5. With the use of any of these systems, a large herd of cows can be fed in just a few minutes each day.

Bedding should be stored close to the resting area in loose housing. It is an excellent practice to store it at one end or along the back wall of the bedded area, where it is readily available as needed.

Storage of feed and bedding for use in stanchion barns is usually handled somewhat differently. Wherever possible, storing hay and bedding above the cows makes possible feeding with a minimum of handling. If this cannot be done, the hay barn and bedding storage should be located as close to the barn as possible. Storing all supplies near the center of the barn reduces the travel required to reach all the animals. Upright silos are ideally located as shown in Figure 11.1. Silo unloaders in upright silos are efficient for larger herds, even if the silage is moved in hand carts after removal from the silo. The size of the herd in which silo unloaders are practical depends upon the relative cost of labor and the depreciation, interest, and operating cost of the machine. A recent study using local prices reported a breakeven point on herds of 80 cows.

Storage of Concentrates

Modern equipment makes the handling of grain in bulk the method of choice on most dairy farms. Many milking parlors have been designed with overhead bins for storage of concentrates, which are fed in the parlor below. An alternative to this storage is a metal tank outside the milking parlor as shown in Figures 11.8 and 11.9. The cost of the tank is usually less than that of constructing bins over the milking parlor. Maintaining free flow of grain from a metal tank is frequently easier than from overhead bins.

For stanchion barns the metal bin also has advantages, although an overhead wooden bin may be satisfactory, since a single large opening may be used to get the grain out, and maintaining flow may not be a serious problem.

and the gutter require bedding. The bedding should be gone over daily, fresh material added at the front, and soiled bedding pushed into the gutter. Requirements for bedding vary greatly with the individual management situation, particularly with the amount of time the cows spend in the barn. A general figure for bedding needs is one ton per cow per year. Loose-housing arrangements require up to 50 per cent more bedding than stanchion barns. Provision must be made for bedding for calves and heifers also. Sufficient amounts should be allowed to keep them clean and dry. Requirements per animal will vary with size.

Exercise for Dairy Cattle

Just how much exercise is important or necessary for dairy cattle is not known. In many instances, cows have been kept confined for long periods with little or no apparent harmful effect. However, it is reasonable to assume that some activity is beneficial and certainly not harmful to cows. Outdoor exercise with exposure to sunlight is important in providing supplies of Vitamin D.

Exercise for the herd is not a problem in loose-housing situations. Where cows are kept in stanchions, it is highly recommended that they be turned into a lot at least once and preferably twice daily. The easier detection of heat is a major benefit from this practice. Those animals subject to lameness and stiffness may also be benefited by having an opportunity to move about part of the day. Cleaning of the barn and adding bedding is much easier with the cows away.

Lots where cattle are turned out should be well drained and free from objects likely to cause foot injury. Foot rot is much better controlled when cattle do not stand in mud. Deep mud can be a significant factor in inducing mastitis in susceptible udders. In fact, cows should be fenced out of mud holes in pastures for these reasons. A good gravel or paved surface is essential for satisfactory lots and walkways.

FURTHER READING

Cleaver, Thayer, H. J. Thompson, and R. C. Yeck, *Stall Barns for Dairy Cattle*, U.S.D.A. Agriculture Information Bulletin 123, 1954.

Cleaver, Thayer, and R. C. Yeck, *Loose Housing for Dairy Cattle*, U.S.D.A. Agriculture Information Bulletin 98, 1953.

Heizer, E. E., "A Summary of Studies Comparing Stanchion and Loose Housing Barns," *Journal of Dairy Science*, 36:281, 1953.

Murley, W. R., and E. W. Culvahouse, "Open Shed and Portable Pens Versus Conventional Housing for Young Dairy Calves," *Journal of Dairy Science*, 41:977, 1958.

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Bedding for Dairy Cattle

Appropriate cleanliness and sanitation for dairy cattle require that clean bedding be provided in any area where they lie down and in the gutter in a stanchion barn. A source of sufficient bedding is often a major problem in a dairy enterprise Usually low-grade or waste materials are used Straw, sawdust, shavings, and peanut hulls are common bedding materials. Other substances may be used where they are locally available. In a stanchion barn, the entire platform where the cows stand

and the gutter require bedding. The bedding should be gone over daily, fresh material added at the front, and soiled bedding pushed into the gutter. Requirements for bedding vary greatly with the individual management situation, particularly with the amount of time the cows spend in the barn. A general figure for bedding needs is one ton per cow per year. Loose-housing arrangements require up to 50 per cent more bedding than stanchion barns. Provision must be made for bedding for calves and heifers also. Sufficient amounts should be allowed to keep them clean and dry. Requirements per animal will vary with size.

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12 The Purebred Business

CLOSELY allied to the milk producing industry, the raising of pure bred dairy cattle offers challenging opportunities and rewards which are found in few other enterprises Leadership in the production aspects of dairying is also found to a large extent among the purebred breeders

Purebred dairy cattle may be defined as those whose ancestors can all be traced back to the foundation animals of the breed. This means that, to be accurately classed as a purebred, an animal must be registered or eligible for registry Most animals with a registered sire and dam are eligible for registry, the only exception being a few which do not meet color specifications or other standards established by the breed associations

PURPOSES OF THE PUREBRED INDUSTRY

Most purebred breeders define their objectives as attempting to improve the quality of cattle, providing breeding stock for other herds and fulfilling a sense of personal satisfaction and accomplishment for the breeder

Records for Purebreds

The accomplishment of these objectives is dependent on a system of complete and authentic records These fall in three categories identification and registration records records of milk production, and records of type classification

Identification and registry The major recording task handled by the breed associations is the identification of the animal and its ancestry These records are initiated by the application for registry of the young animal by its owner The name and number of the sire and dam, and breeding date, birth date, and identifying information on the calf, are required In cases where the calf is the result of artificial insemination by a technician of a semen-distributing organization a copy of the breeding certificate signed by the authorized technician, must accompany the application for registry The applicant also suggests a name for the young animal.

The owner, or breeder, as appropriate, must certify the accuracy of all information on the application for registry. The methods employed by the registry associations to assure accuracy have resulted in their records being regarded as highly reliable. Severe punitive action is taken by the associations against individuals proved to have knowingly violated their registry regulations.

Following receipt, checking, and recording of the application for registry, a number is assigned to the animal, and approval is given to the name if it is within the requirements of the association. A certificate of registry is issued to the owner carrying complete information on the identification of the animal and its name and number.

Records of milk and fat production. The breed associations grant to breeders which qualify the privilege of measuring and recording the milk and fat production of registered cattle. Records made under the breed programs are certified as "official," and may be used in advertising and promoting cattle. However, their greatest value lies in careful use by the breeder in selecting those cows which have the ability for high production and, even more important, have the ability to pass it to their offspring.

More information on the details of obtaining production information is covered in Chapter 7. The use of these records in selection and culling is discussed in Chapter 9. The accuracy maintained in production records is equal to that required for identification and registry.

Herd Improvement Registry is an important activity of all the breed associations. Dairy Herd Improvement Registry is being used to an increasing degree, and appears likely to become the most important program in the future. Advanced Registry testing is of minor importance with all of the breeds.

Type-classification records. Each of the breed associations has established standards of body conformation considered ideal for the breed. Details of these standards, and the obtaining of information on individual animals, are considered in Chapter 8. Each of the associations also provides a program of classification and recording for the benefit of breeders. Records are certified as representing the actual type of the animal on the date observed, since accidents or age may change the characteristics. Classification records are used as a basis for selection of breeding stock as well as for promotion of individual animals and herds.

Improvement of Quality of Purebred Cattle

The conscientious purebred breeder is not merely a propagator of registered cattle. He makes a diligent effort to improve the quality of each succeeding generation of his cattle. Establishment of goals, and

the intelligent utilization of all the records available to him are essential to accomplish improvement Not only must outstanding animals be recognized and used for breeding but rigid culling must be practiced where it is necessary, to remove animals exhibiting poor merit

Supplying seed stock to other herds Once outstanding cattle are developed they make their greatest contributions by serving as foundation breeding animals Many purebred herds through the use of sound improvement practices have developed a reputation for cattle of high merit Operators of commercial herds look to these herds as sources of inheritance to improve the usefulness of their own cattle The use of purebred cattle to supply seed stock for commercial herds is the greatest source of the strength of the purebred business

HISTORY AND DEVELOPMENT OF PUREBRED BREEDS

The ancestry of all the important dairy breeds in this country can be traced back to cattle originating in Europe the British Isles and the islands lying between them These cattle were developed from the early domestication of wild cattle in the area and as a result of considerable intermingling of cattle as different cultures and peoples in turn dominated various areas

Two wild forms of cattle are credited with providing the ancestry of modern European breeds They are *Bos primigenius* and *Bos longifrons* *Bos primigenius* was apparently common to Europe parts of Asia, and northern Africa It was a large cow with a height of six feet or more Long horns were a characteristic of the *Bos primigenius* Wild representatives of this group may have survived in Europe as late as the seventeenth century The *Bos longifrons* was a smaller animal with short horns It also was widely distributed in Europe and was known in the British Isles in Roman times Two other groups of cattle identified in early Europe are *Bos frontosus* and *Bos brachycephalus* These may also have played a part in the early ancestry of modern cattle

All present European breeds fall in the generic category of *Bos typicus* They are differentiated from the *Bos indicus*, which includes the modern humped cattle of India

Isolation of groups of people in fairly small areas led to varying degrees of close breeding and fixation of the characteristics of the breeds as we know them today Climatic conditions and available feed as well as the standards established by the people involved determined which individuals survived While the background of present breeds goes back for centuries it is only during the last few hundred years that some have been kept as the breeds known today

Individual Breeds

The desired physical characteristics of the major breeds are presented in Chapter 8; other details are given below.

Ayrshire breed. This breed takes its name from the country of Ayr in southwest Scotland, where it was developed. It is believed to have ancestry in both the *Bos primigenius* and *Bos longifrons* cattle. It apparently is the result of crossings involving Friesian cattle from Europe, animals from the Channel Islands, and Teeswater cattle of Scotland. The Ayrshire is a relatively nervous breed and is known for its hardiness and good grazing ability, developed under the rugged terrain and climate of Scotland.

The Unified Score Card indicates the following breed characteristics:

> "Strong and robust, showing constitution and vigor, symmetry, style and balance throughout, and characterized by stiongly attached, evenly balanced, well-shaped udder.
>
> *Color*—Light to deep cherry red, mahogany, brown, or a combination of any of these colors with white, or white alone; distinctive red and white markings preferred, black or brindle objectionable.
>
> *Size*—A mature cow in milk should weigh at least 1,200 pounds.
>
> *Horns*—Inclining upward, defined, medium length and tapered toward tips. No discrimination for absence of horns."

The milk of the Ayrshire breed averages 4.0 per cent fat and 12.7 per cent total solids. Ayrshires produce a white milk with relatively small fat particles. Average production of Ayrshires on herd testing for 1960 was 10,808 M, 446 F, 305d 2x M.E. A representative high-producing Ayrshire cow is pictured in Figure 12.1.

Records for the Ayrshire breed in the United States are kept by the Ayrshire Breeder's Association, organized in 1875. It has its headquarters at Brandon, Vermont. Production testing, herd classification, and promotion and recognition programs for outstanding animals are all carried out by the Association. The *Ayrshire Digest* is published monthly by the Ayrshire Breeder's Association. Details of specific programs are available from the Association. Registration during 1960 totaled 16,831 animals. There were 4,034 animals classified in 1960.

Brown Swiss breed. This is the oldest of the present breeds. Records, and relics which have been found in ruins left by the Swiss Lake Dwellers, indicate its presence previous to the start of our present calendar. The *Bos longifrons* was apparently the principal ancestor of the Brown Swiss. In its native home, in Switzerland, this breed served as a source of milk, meat, and labor. It developed in a rugged mountainous country, which fact accounts for its extremely strong constitution and hardiness.

Figure 12.1 An outstanding Ayrshire cow, Park Agr Fortune 440781 (E), average of three lactations 15,393M, 592F, 2x 305d M. E. Classified excellent Courtesy Ayrshire Breeder's Association

The following breed characteristics are listed on the Unified Score card

"Strong and vigorous, but not coarse Size and ruggedness with quality desired Extreme refinement undesirable

Color—Solid brown varying from very light to dark. White or off-color spots objectionable Females with any white or off-color markings above the under side of the belly, or with white core in switch, do not meet color standards of the Brown Swiss breed and shall be so designated when registered Pink noses and light streaks up the side of the face objectionable

Size—The minimum weight for mature cows should be about 1,400 pounds

Horns—Incurving and inclining slightly up Of medium length, lacking coarseness, tapering toward tips Polled animals not barred from registry No discrimination for absence of horns"

Calves are usually nearly white at birth and become darker with age. Calves are large, weighing 90 or more pounds at birth. They are excellent for veal production. Brown Swiss cows rank among the best of the dairy breeds for beef production Figure 12.2 presents a picture of a high producing Brown Swiss cow of excellent type

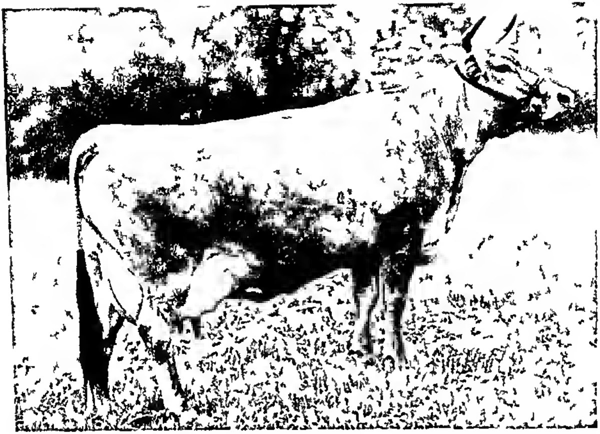

Figure 12 2 An outstanding Brown Swiss cow Lee s Hill Keeper s Raven 171673 at one time holder of the world s butterfat production record 34 850M 1579 3 F 365d 3x Class fied excellent Courtesy Brown Swiss Cattle Breeder s Association

In the United States the breed has developed from a relatively small base with not quite 200 animals making up the total importation Selection has been for increased refinement and dairy character as compared to the Brown Swiss found in Switzerland Milk of the Brown Swiss averages about 4 0 fat and 13 0 per cent total solids

Records for the Brown Swiss are kept by the Brown Swiss Cattle Breeders' Association, Beloit, Wisconsin The Association publishes a monthly magazine *The Brown Swiss Bulletin* Record of Production (AR), Herd Improvement Registry and Dairy Herd Improvement Registry are testing programs conducted by the association Average production of mature cows on Herd Test in 1960 was 10 854 pounds of milk and 438 pounds of fat, 2x

A total of 23 949 new registration certificates were issued in 1960 One thousand seven hundred seventeen animals were classified during that year

For a short period the Brown Swiss Herd Book was opened to the fourth generation descendants of animals showing typical breed characteristics and meeting high standards for type and production Only a few animals were registered in this program

The Guernsey breed This breed was developed on and named from, one of the islands between France and England in the English Chan

nel Guernsey is a small island, where the principal industry is raising truck and greenhouse crops Cattle are believed to have been brought to the island from Normandy and Brittany in France The first Herd Book was established on the Island in 1879 Cattle from the islands of Sark and Hern nearby are also registered in the Herd Book. In 1824, laws were enacted which prohibited bringing cattle to the Island except for immediate slaughter

The Unified Score Card carries the following breed characteristics for Guernseys

"Size and strength with quality and character desired

Color—A shade of fawn with white markings clearly defined Skin should show golden yellow pigmentation When other points are equal, a clear (buff) muzzle will be favored over a smoky or black muzzle

Size—A mature cow in milk should weigh at least 1,100 pounds "In milk" means normal condition after having been in milk from 3 to 6 months

Horns—No discrimination for absence of horns "

Milk from the Guernsey is noted for its high fat content, yellow color, and large fat globules Average composition is about 4 98 per cent fat and 14 5 per cent total solids Average production on herd test in 1960 was 9,246 pounds milk and 449 pounds fat 2x ME

Bos longifrons provided the major ancestry of the Guernsey breed Numerous importations have been made to this country, since there are no disease conditions on the islands which make it necessary to restrict them

Calves of the Guernsey breed weigh about 75 pounds at birth and require careful attention in early life Cows and calves of this breed are of moderate value as producers of beef and veal

Records for the Guernsey breed in this country are maintained by the American Guernsey Cattle Club, with headquarters in Peterborough, New Hampshire It was organized in 1877 Registrations in 1960 amounted to 4,382 males and 58,509 females Classifications involved 16,139 animals

Recognition programs include Gold Star Guernsey Sire, Gold Star Guernsey Dam, and Gold Star Breeder awards Outstanding production is also recognized by the publicizing of "class leaders," the ten animals having the highest production in their age groups

Production testing programs sponsored by the Breed Association include AR, HIR and DHIR. Production and classification information and some show winnings are published in the *Performance Register* The *Guernsey Breeders Journal* is published twice monthly by the Association at Peterborough Figure 12.3 contains a picture of an outstanding Guernsey cow

The Breed Association has recognized the high fat and solids content of Guernsey milk as well as its yellow color by copyrighting the name

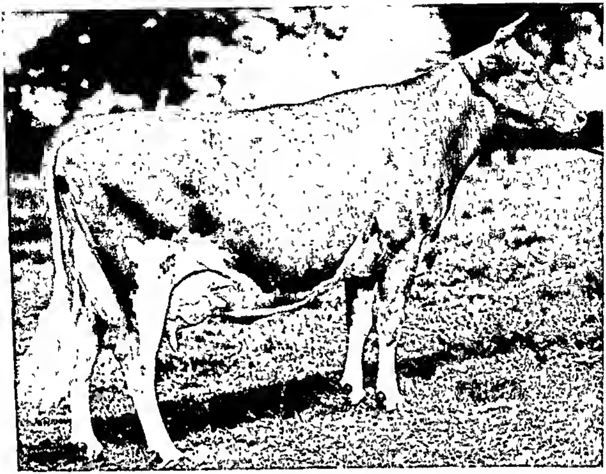

Figure 12.3. An outstanding Guernsey cow, Lush Acres Hermes' Quest 1431732. Average production for her first four lactations: 15,205M, 919F. Highest classification in the Guernsey breed, excellent (95). Courtesy American Guernsey Cattle Club.

"Golden Guernsey" for Guernsey milk produced and processed according to its specifications. Guernz Gold and Guernsey Royal are also trademarks of this organization. Excellent promotional work has been done with these products, resulting in premium markets for producers in some areas.

The Holstein-Friesian breed. The Holstein-Friesian breed originated in Holland, particularly in the provinces of North Holland and West Friesland. *Bos primigenius* is thought to be its principal ancestor. Luxuriant grazing is available in Holland, and the Holstein-Friesian breed was developed to make use of it. Typically the breed exhibits an even and amiable temperament. Characteristics of the Holstein breed, listed on the Unified Score Card are as follows:

"Rugged, feminine qualities in an alert cow possessing Holstein size and vigor.

Color—Black and white markings clearly defined. Color markings that bar registry are solid black, solid white, black in switch, black belly, black encircling leg touching hoof head, black from hoof to knee or hock, black and white intermixed to give color other than distinct black and white.

Size—A mature cow in milk should weigh at least 1,500 pounds.

Horns—No discrimination for absence of horns."

Calves of this breed are large and rugged, averaging about 90 pounds at birth Reasonably good fleshing and white color of fat place the Holstein among the better producers of dairy beef and veal

Milk of the Holstein Friesian breed averages about 3 6 per cent in fat and 12 5 per cent total solids Cows on herd test averaged 13,613 pounds milk and 503 pounds fat (2x, 305 day M E) in 1960 An outstanding cow of this breed is pictured in Figure 12 4

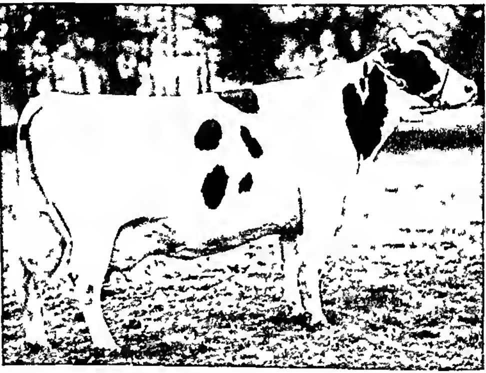

Figure 12.4 An outstanding cow of the Holstein Friesian breed Princess Breezewood R A Patsy 382 6059 holder of the world s record for butterfat production 36 821M 1 866F 365d 2x Classified Good Plus Courtesy The Holstein-Friesian Association of America

The Holstein Friesian Association of America with headquarters at Brattleboro, Vermont, is the Registry Association of the breed. It was organized in 1885 by the merger of two earlier associations

The usual testing programs are made available by the Association Official production records as well as herd lactation averages are pub lished in the *Type and Production Year Book.*

Herd classification involved the inspection of 55 906 animals in 1960

Recognition programs of the Holstein Friesian Association include Progressive Breeders Registry, Gold Medal Dams, Silver Medal Type and Silver Medal Production for sires, and Gold Medal Sires Details of these programs are available from the Association

Registration in 1960 totaled 23,983 males and 241,878 females.

The *Holstein-Friesian World* is the news organ of the breed, but is published by an independent organization, The Holstein-Friesian World, Inc., at Lacona, New York.

The Jersey breed. The history of the Jersey breed is similar to that of the Guernsey, to which it is closely related. The Island of Jersey is about 22 miles southeast of Guernsey. It is believed that the cattle which produced the Jersey also came from the provinces of Brittany and Normandy. *Bos longifrons* provided the early ancestry. Cattle were restricted from importation except for slaughter starting in 1789. This has allowed a considerable period for developing a uniform breed.

The Unified Score Card carries the following characteristics for the Jersey Breed:

"Sharpness with strength indicating productive efficiency.
Color—A shade of fawn, with or without white markings.
Size—A mature cow in milk should weigh about 1,000 pounds.
Horns—Incurving, refined, medium length and tapering toward tips. No discrimination for absence of horns."

Milk from the Jersey is the highest in fat percentage of any of the breeds, averaging about 5.3 per cent. Total solids average about 14.9 per cent. It is yellow in color. Animals on herd test in 1960 averaged 8,889 pounds milk and 471 pounds fat 2x ME.

Calves average about 55 to 60 pounds at birth and require careful attention during early life. Intensive selection for dairy characteristics has resulted in an animal producing minimum amounts of beef and veal. Figure 12.5 presents an outstanding Jersey cow.

Records for the Jersey breed are maintained by the American Jersey Cattle Club, 1521 E. Broad Street, Columbus 5, Ohio.

Herd classification involved the inspection of some 48,435 animals in 1960. New registrations totaled 55,997 animals. Testing programs available to breeders include Registry of Merit (AR), HIR, and DHIR. Recognition programs for outstanding animals include a series of certificates issued for high production. Special designations are given to bulls based upon production and type classification ratings of their daughters, and for unproven young bulls based upon the performance of their ancestors. Constructive breeder certificates are awarded to herd owners whose herds meet certain standards. Two special awards are given annually: The Master Breeders Award and the Distinguished Service Award. Production and classification information is published in the *Jersey Performance Register.*

A promotion program, All-Jersey, is conducted by the Association under a separate organization, All-Jersey, Inc. It is a promotion of a special market for milk and dairy products from the Jersey, based on the high nutritive content of the milk. In some areas the program has

Figure 12.5 An outstanding Jersey cow Marlu Milady Eight lactations average 18 828M 873F Classified excellent Courtesy The American Jersey Cattle Club

been quite successful in promoting milk and increasing the demand for Jersey cattle

A bi monthly magazine *The Jersey Journal* is the official news organ of the Association

The Pure Bred Dairy Cattle Association (PDCA)

This organization is made up of representatives of the five major dairy breeds It has performed many useful services in bringing uni formity into the activities of the individual associations Programs and policies in regard to breed shows and sales are discussed and reviewed A statement of approved practices and procedures for sales has been developed by the group Activities of the PDCA in the areas of produc tion testing type-evaluation and artificial insemination have been cov ered in the chapters on those subjects The address of this organization is Peterborough New Hampshire

Dual Purpose Breeds

Milking Shorthorn breed Milking Shorthorns are considered a dual purpose breed kept for the production of both meat and milk. In size

the milking Shorthorn is comparable to the Holstein. Its color may be solid red, solid white, red with white spots, or roan.

The Shorthorn breed originated in northwestern England, from cattle probably brought in by the numerous invaders over several centuries. Originally, they were known as Durhams, from one of the counties in the area. These cattle participated heavily in the work of early English breeders. Many of the early advances in developing cattle for both milk and beef production were with Durhams. Milk of the Shorthorns averages 4.0 per cent in fat. Considerable variation in the milk-producing ability exists in the breed because of selection for the dual characteristics.

Figure 12.6. The true type Milking Shorthorn cow. Courtesy The American Milking Shorthorn Society.

Increasing emphasis is being placed on milk production within the Shorthorn breed. A picture of the True Type Milking Shorthorn is presented in Figure 12.6. Figure 12.7 presents an outstanding cow of the breed.

Records for the breed are kept by the American Milking Shorthorn Society, 313 S. Glenstone, Springfield, Missouri. The *Milking Shorthorn Journal* is published by the breed association.

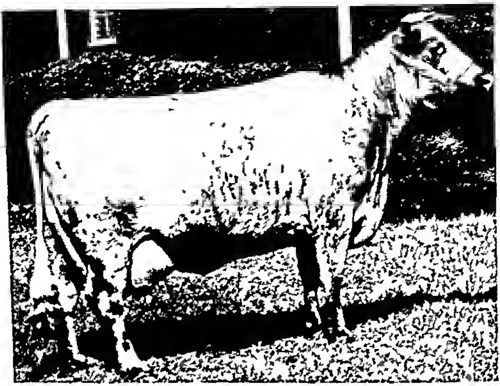

Figure 12 7 An outstanding Milking Shorthorn cow, Fors Fairy Lou Four lactations average 12,631M, 452F Courtesy The American Milking Shorthorn Society

Minor Breeds

There are a number of breeds of cattle kept for milk production which are confined to local areas in the United States or are maintained in small numbers Among these are the Red Polled and Red Danes The Red Polled is a dual purpose breed, originating in eastern England. In the United States they are found in the Midwest and Southwest. Being a dual purpose breed, they exhibit good beef qualities and considerable variability in milk production As implied by the name, cattle of this breed are red in color and have no horns

The recording association is the Red Polled Cattle Club of America, 3275 Holdrege Street, Lincoln 3, Nebraska.

The Red Dane is the predominant breed in Denmark. In the United States it is found principally in the North Central part of the country. The cattle are solid red, and produce milk of about 4 0 per cent fat. Red Danes in the United States are the result of imported bulls crossed on other dairy breeds The American Red Danish Cattle Association is the registry organization and has its headquarters at Marlette, Michigan

There are many other breeds found in Europe and the British Isles kept for milk or beef purposes Most of them are not present in the

United States in significant numbers. Space does not permit describing them here.

Merchandising Purebred Dairy Cattle

Success in merchandising purebred dairy cattle is based upon the same principles which apply to any other industry, that is, maintaining a high-quality product, properly presented to potential consumers for their consideration and purchase.

The importance of quality and dependability of performance in purebred dairy cattle cannot be overemphasized. Methods of evaluating producing ability and type in cattle and techniques of improving them are discussed elsewhere in this book.

Once top performance and quality are achieved, potential buyers must be made aware of its existence. A number of avenues are open to the breeders of purebred cattle. These include participation in breed sales and breed shows, advertising in breed and trade publications, and direct and local advertising.

Full participation in breed programs for evaluating production and type is essential. In addition, information obtained from the Dairy Herd Improvement Program is also helpful.

Advertising in breed and trade journals. Breed publications are read by nearly all people with an active interest in a given breed and those with a broad interest in dairy cattle. Clear-cut, well-designed advertisements based on accurate information in these journals constitute one of the best ways to present cattle to the public. In addition, there are a number of trade publications read by commercial dairymen where advertising can be beneficial.

Development of a trademark. Just as each breed has its identifying signs, a similar identification is needed for successful promotion by individual breeders. Selection of a striking farm prefix and including it in the name of all cattle is important. Of course only top-quality animals and sound, reliable practices must be associated with the trademark.

Participation in shows and sales. The show ring is designed to acquaint breeders and the public with the standards for type within a breed and to present cattle which approach these standards to the public. With the strong market existing for good type, it is important for the breeder who has developed animals of good type to participate in these activities. There is probably no better way of obtaining publicity for a herd. The breeder may enter this field by exhibiting at local shows and field days. As the type of his cattle improves and he gains experience in show-ring technique, which is a highly skilled art, he can progress to larger shows. Figure 12.8 shows the "line-up" of a class of superior animals at a national show.

Figure 12 8. The Ayrshire futurity class of 1960 Courtesy The Ayrshire Breeder's Association.

Breed Sales

In most areas the local breed associations sponsor sales of selected cattle consigned from various herds. These sales provide an opportunity for buyers to review large numbers of cattle, and frequently many are attracted to such a sale. Presenting outstanding cattle to the public through such a medium is an excellent practice. Breed sales should not be used to cull off the bottom of the herd. In fact, if a breeder is to maintain a good reputation over a period of years, no animals should be sold for dairy purposes which are not good enough to remain in the breeder's herd. In purchasing and trading animals, pricing should be on a realistic basis in relation to the merit of the individual. Much harm can be done to the purebred business by buying and selling of cattle among breeders at unrealistic prices.

Sales Practices and Procedures, by the P.D C.A., sets forth a standard of operation for breed sales. Most breed sales are conducted according to this standard. Those interested in purebred sales can learn what to expect from them by reviewing this publication, which is listed at the end of the chapter.

Choosing a Breed

The newcomer to the purebred business frequently has a problem in choosing the breed best suited to his needs. Factors that should be

considered in making this decision are the market for milk, purebred breeds common in the area, breeds of interest to commercial dairymen in the neighborhood, and the personal interest of the breeder.

There are advantages to choosing the breed which predominates in an area, since it already has proved to be well adapted and accepted there. Opportunities to participate in co-operative promotional and selling programs are apt to be greater.

The importance of a breed or breeds being preferred by commercial dairymen is frequently overlooked The greatest strength of the purebred business lies in supplying stock to commercial producers, since they make up by far the largest percentage of the dairy business. Outstanding purebred herds may find their best market in other purebred herds, but the broad market base rests with the commercial dairyman.

Enthusiasm for a particular breed may be an overriding factor in selection. However, one should recognize the importance of economic and marketing factors.

While milk may constitute the less important part of business in some outstanding purebred herds, it is a major factor in many. This is certainly true for the beginning breeder who may need to depend on milk sales for a number of years while becoming established. For these reasons, the demands of the local milk market should be considered in any selection of a breed of purebred dairy cattle

FURTHER READING

The American Guernsey Cattle Club, *The Story of 10 Centuries A Brief History of the Guernsey Breed of Dairy Cattle* Peterborough, New Hampshire: The American Guernsey Cattle Club

The Purebred Dairy Cattle Association, *Sales Practices and Procedures*, Peterborough, New Hampshire. Published by the Association, 1959

Spearing, Jack, *Fitting and Showing Dairy Cattle*, Ames, Iowa: Iowa State College Press, 1952

13 Commercial Milk Production

SUCCESS in the production of milk is dependent upon a high quality product efficient management of the herd souod business management and an adequate market Each of these is discussed in this section

PRODUCING HIGH-QUALITY MILK

High quality milk is the natural product of a bealthy mammary gland uncontaminated with excessive bacteria off flavors dirt or medications The most important requirement for high quality milk is complete cleanliness and sanitation throughout the operation Cleanliness starts with the cow Udders flanks thighs and tails should be clipped and trimmed to remove excess hair which traps dirt Adequate bedding supplies and manure removal are essential Wasbing the udder and teats and use of a strip cup are important practices in producing clean milk

Care and Cleaning of Equipment

Equipment used in handling milk and for milking is a frequent source of bacterial contamination The milking machine should be completely broken down and thoroughly cleaned following each milking Good cleaning practices involve the following immediately after milking rinse the milker with cool or slightly warm water (Hot water used at this time tends to cause milk to stick on the surfaces) This rinsing is best done by dousing the teat cups in a bucket of water so that a mixture of air and water provide some scrubbing action in the machine Rinse water must not enter and cootaminate the milk supply All surfaces should then be cleaoed by scrubbing with a suitable brush aod a solution of a good dairy cleanser and hot water Final rinsing should be with hot water at sterilizing temperatures Milker buckets and parts should be stored completely dry and where they will be free from dust and

other sources of contamination. Just before each milking, the machine and other equipment should be rinsed with a standard chlorine or other sanitizing solution.

Inflations and rubber parts. Special care is necessary for rubber parts of milkers. Because of the porous nature of rubber, milk fat accumulates in tiny cracks and serves as a source of bacterial contamination, as well as weakening and shortening the life of the inflations of the teat cups and the tubing. Inflations and tubing should be cleaned as described above. In addition, they should be boiled weekly in a solution of lye to remove accumulated fat. Use of two sets of inflations in alternate weeks is an excellent practice. The set not in use should be stored in a cool, dry place after boiling in a lye solution.

Pipelines through which milk flows may be taken down for cleaning or cleaned in place, according to manufacturers instructions, depending upon their design. Bulk tanks should be cleaned in the same manner as milking machine parts, immediately after the milk is picked up. The tank should be rinsed with a suitable sanitizer such as a standard chlorine solution before milk is put in after each cleaning. Cans for the shipping of milk are usually cleaned at the plant; however they also should be sanitized by rinsing before being filled with milk.

A frequently neglected source of contamination is the vacuum line. Condensation or accidental drawing-over of milk results in liquid in the line which may drain into the milk supply. A regular flushing with a strong lye solution, followed by careful draining, will not only maintain good sanitation but assure efficient mechanical operation. Weekly treatment is recommended.

Extreme care should be followed in all cleaning and sanitizing operations that water is not allowed to enter the milk supply and adulterate it.

Bacterial Standards for Milk

Bacterial standards for milk are established by the local health authority in most areas. There is considerable variation in these from place to place. Some areas require that milk contain not over 100,000 bacteria per ml. on delivery, and the temperature of the milk be not above 45 to 50° F. The United States Public Health Service has published suggested uniform regulations of not over 200,000 bacteria per ml. on delivery and a maximum temperature of 50° F.

Immediate cooling. Since some bacteria are present in practically all milk, action to retard their growth is necessary. Cooling milk as rapidly as possible to 50° F or below is a recommended practice. Most commercial cooling apparatus, either tanks or can coolers, are designed to do this. However, constant checking is essential to assure that they are functioning properly.

Odors and Flavors in Milk

Milk is subject to undesirable odors and flavors from a number of sources Any of them are objectionable and reduce the flavor quality of milk Control of feed flavors is discussed in Chapter 2 Generally, keeping the cow from exposure to these flavors for four hours prior to milking will control them

Oxidative changes in the fat of milk can result in very objectionable flavors, including chalky, cardboard, stale, and fishy or oily flavors Cows in late lactation may produce milk more susceptible to these changes The milk of some individual cows may also be a problem Agitation of the milk to an excessive degree or alternate warming and cooling of milk tend to stimulate oxidative flavors Adequate control of cooling the milk, and the elimination of risers in pipelines or other sources of agitation, help to eliminate flavors due to oxidation

Preventing Contamination of Milk

Milk may be contaminated by dirt, diseases of the udder, medications given the cow, or chemicals used in feed production or processing Procedures for keeping dirt out of milk and the importance of doing so are self-evident. Milk from cows with mastitis should not be sold for human consumption, and most health regulations require that cows with mastitis be removed from the milking string

The Federal Food and Drug Administration and several state health departments have ruled that milk offered for human consumption shall contain no residues from antibiotics or other medications used on cows Likewise, chemicals used for herbicides and pesticides on or near animals or forages must not appear in milk. Feed additives which may appear as a residue in milk are not allowed When medications which may appear in milk are used on milking cows, milk must be withheld from sale for the time prescribed on the label Only approved fly control, grub control, or internal parasite control measures may be used on lactating cows Forages or grains treated with chemicals which appear in milk should not be fed lactating cows

EFFICIENT MANAGEMENT OF THE DAIRY HERD

Many of the details important to efficient management are covered in the sections on feeding, reproduction, diseases, selection, housing, and other subjects Obtaining optimum production from dairy cattle requires the attention of experienced management There is no substitute for knowledge of individual cow response to management practices

Modern procedures, involving automation wherever possible, are necessary for economical operation. However, because of the variation between dairy cows, some individual observation and treatment are essential.

Establishing Optimum Herd Size

One of the most difficult problems in the management of a milk-producing business is determining the size of herd which is most efficient. There are a number of factors which are related to any decision on herd size. They include the degree of management and supervision available, labor, physical facilities, production level in the herd, type and size of market, and capital available. Only after evaluation of each of these factors can a satisfactory decision be made.

Management. The importance of management capacity available to a herd is frequently overlooked. Management of the business aspects of the operation, as well as caring for the cattle, is important. Most contemplated changes in herd size are in the direction of enlargement. Frequently the man who does a satisfactory job with a relatively small herd finds it difficult to handle a larger herd equally well. Management problems are increased in larger herds, as reflected by the fact that average production rates of individual cows tend to decrease as the numbers in a herd become greater.

There are, of course, many instances where the management ability available is sufficient to handle a much larger herd than is currently present. A realistic evaluation of management needs should be made for every dairy operation and appropriate action taken to assure the presence of adequate ability.

Physical facilities. Buildings and equipment available are frequently the chief factor in establishing herd size. Poor sanitation and poor feeding and milking procedures frequently result from keeping more cows than housing is designed for. On the other hand, using housing facilities at a rate much below capacity makes the interest and depreciation charges for each cow excessively high. Labor and all the other factors involved frequently adjust to the housing available.

This can lead to inefficiencies in operation which may be more costly than making adjustments in housing. Because of the high original cost of housing and difficulties involved in remodeling, changes are made only at infrequent intervals. It is important, in establishing a dairy enterprise, that buildings be as flexible and adaptable as possible, to allow for adjustments in herd size or use for other enterprises.

Labor-saving devices and equipment for the mechanical handling of materials used in the dairy enterprise are becoming increasingly important. Using these machines is really an exchange of capital investment

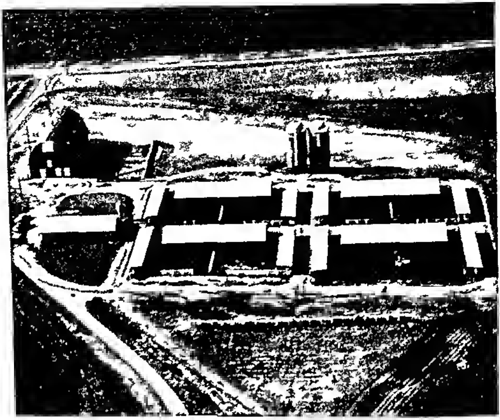

Figure 13 1 A modern milk producing plant incorporates a high degree of efficiency in labor and handling of materials in its design

and expense for the use of labor Since the cost of purchase and maintenance and operation of much equipment is high careful evaluation should be made of the size of the herd necessary to support it economically One of the pressures behind the present trend toward larger herds is the need to make more efficient use of labor saving equipment

Labor Labor costs are becoming an increasingly important factor in the milk producing industry as well as in the production of most other commodities Efficient management of labor is essential to successful dairy production The continuous requirement for attention of dairy cows makes the problem of labor management especially complicated Adherence to a five day work week and usual holidays, which is becoming increasingly frequent, requires that approximately three men be employed for every two men at work each day

Standards of labor efficiency in dairying are difficult to establish because of the varying conditions between areas and farms However, it appears that a man working full time in dairying should care for a minimum of 40 cows In especially well organized operations he may be able to care for 60 cows When provision is made for days off and

so forth, the cows per man employed will be somewhat lower. The quality of labor is important in dairying. More is to be lost than saved by the use of unreliable or poorly skilled labor merely because it is cheap.

When increases in the size of a herd are contemplated, it may be well to plan in terms of labor units. Changing to a herd of such a size that the labor available cannot adequately care for the animals can make the operation quite inefficient, especially if an additional man is not fully occupied.

Production level. Frequently, when it is desirable to increase milk production, the first thought is to add more cows to the herd. This may not be the most desirable procedure unless the production level of the present herd is reasonably high. Frequently, increasing average production per cow will increase income much more rapidly than merely adding more cows. A herd of 30 cows with an average annual production of 12,000 pounds of milk, or an annual total of 360,000 pounds, is to be preferred to one of 40 cows, of the same breed, with an average annual production of 9,000 pounds for the same total.

The average production rate at which it may be more profitable to add more cows varies with the local situation. Production should be above the average for the type of herd involved, and the average cow certainly should be paying all expenses of production and returning some profit. A system for calculating costs of production and profit is presented in the next section.

Average annual production of cows in herds on D.H.I.A. testing is above 10,000 pounds of milk and 400 pounds of fat. Certainly a herd should be producing at this rate or higher before expansion is considered in most areas. At the upper level, increasing average annual production above 13,500 pounds of four per cent milk or its equivalent requires rather intensive management activity for a commercial operation.

Market. Herd expansion will not be profitable unless the additional milk can be sold at a satisfactory price. The factors which are of importance in this regard are discussed in Chapter 14.

Business Management of the Dairy Herd

The application of sound business principles to a dairy operation is equally as important as proper handling of the animals. The greatest deficiency in the operation of many dairy herds is failure to recognize the sources of all the costs involved and to properly evaluate them. Fully half of the existing dairy production enterprises do not pay their costs of operation and provide a reasonable return on investment, labor, and management. Careful evaluation of the financial aspects of the dairy

enterprise is particularly important because of the long-term nature of the business and the relative difficulty in making sudden adjustments.

It is not possible to provide accurate cost and return figures for dairy operations in various areas because of the tremendous variations which exist. The following model may serve as a basis for calculating the cost of production on a given cow or herd situation by substituting local values. It is set up on the basis of separating the dairy operation from any feed raising enterprise on the farm. Investment in land (except for buildings and lots) is not included. Charges are made for all feed consumed.

The breakeven point for profitable production under the conditions of the model is at just over 9,000 pounds of four per cent milk. Obviously, many dairy herds operate at lower levels of average production. If production costs are reduced from those shown in the model, this can be sound business. In other circumstances, while they may provide a reasonable living for the operator, a sacrifice is being taken in labor income, interest on investment, or depreciation. While this situation can be tolerated for short periods, no good business can operate on this basis over several years.

It is interesting to note how rapidly management income or profit increases after production levels rise above the breakeven point. Analysis of records of actual milk production enterprises indicates this is the usual case.

No attempt has been made in the model to account for the costs that more intensive management, required to raise production, would entail. Undoubtedly labor and other costs will increase However, the rise in costs can be expected to be much less than the increase in profits.

The purebred breeder who uses this type of model for evaluating his business will need to modify it in terms of the investment in individual cows, the value of calves, and income from selling breeding stock. The inclusion of these items makes the attainment of high production levels equally as critical in the purebred herd as in the commercial one, since the sale value of purebred cattle is based to a high degree on proved producing ability.

Miscellaneous Management Consideration

There are several miscellaneous items which frequently call for decisions by the management of a dairy herd. A few of these are discussed in this section.

A sound market for milk. The major characteristics of milk marketing are discussed in Chapter 14. When deciding on a location for a dairy operation, the type of market available becomes extremely important. A difference of a few cents in the price per 100 pounds of milk has a

Model for Calculating Annual Costs and Returns on a Per Cow Basis in a Dairy Operation

Investment Required for:		
Cow:		$ 350.00
Buildings, housing, feeding, milking:		450.00
Equipment:		200.00
Total investment		$1,000.00
Interest on investment @ 5%:	$ 50.00	
Depreciation on cow, based upon 3 5 years in the herd, $150.00 salvage value:	57.00	
Depreciation on building; 30 year life:	15.00	
Depreciation on equipment; 10 year life:	20.00	
Taxes on cow, buildings and equipment:	25.00	
Insurance on cow, buildings and equipment:	3.00	
Veterinary fees and medications:	8.00	
Breeding fee:	6.00	
Labor for care of cow and milking:	80.00	
Bedding, one ton per year:	20.00	
Feed to maintain a 1,200 pound cow @ 2.5¢ per pound of T.D.N.:	80.00	
Feed to produce one calf per year @ 2.5¢ per pound of T.D.N.:	11.00	
Total cost of mointaining a cow ond producing o colf:	375.00	
Feed cost to produce 6,000 pounds of 4% milk at 2.5¢ per pound T.D.N.:	48.00	
Total annual cost to keep a cow producing 6,000 pounds of 4% milk:		423.00
Cost of feed to produce 9,000 pounds of 4% milk at 2 5¢ per pound of T.D.N.:	78.00 [a]	
Total annual cost of keeping n cow producing 9,000 pounds of 4% milk:		453.00
Cost of feed to produce 12,000 pounds of 4% milk at 2.5¢ per pound of T.D.N.:	110.00 [a]	
Total annual cost of keeping a cow producing 1,200 pounds of 4% milk:		485.00
Cost of feed to produce 15,000 pounds of 4% milk at 2.5¢ per pound of T.D.N.:	145.00 [a]	
Total annual cost of keeping a cow producing 15,000 pounds of 4% milk:		520.00

[a] Feed requirement has been adjusted upward at higher rates of production to account for any loss in feed efficiency.

Projected Annual Profit and Cost of Production for a Cow Producing at Varying Levels

Item	Income	Cost of Production	Difference (Profit)
6,000 pounds 4% milk [b]			
9 calf annually	$ 20 00		
Milk @ 4 7¢ per pound	282 00		
Total income	302 00	$423 00	$–(121 00)
9,000 pounds 4% milk [b]			
9 calf annually	20 00		
Milk @ 4 7¢ per pound	423 00		
Total income	443 00	453 00	–(10 00)
12,000 pounds 4% milk [b]			
9 calf annually	20 00		
Milk @ 4 7¢ per pound	564 00		
Total income	584 00	485 00	99 00
15,000 pounds 4% milk [b]			
9 calf annually	30 00 [c]		
Milk @ 4 7¢ per pound	705 00		
Total income	735 00	520 00	215 00

[b] No income is listed for manure since the labor and costs for handling frequently equal its value It should be given credit where it has a value

[c] Calves from herds at this level of production frequently bring premium prices

dramatic effect on profits However, equally important is the stability of the market Price wars and sudden changes in the supply of milk can be extremely damaging to producers The market should have sound and expandable outlets for classes II and III, or surplus, milk, so that moderate increases in milk supplies do not severely depress prices locally Careful study and evaluation of local markets and logical adjustments to them are essential for a successful milk producing business

Providing forage for the dairy herd in summer. One of the strong points of the dairy cow in our economy has been her ability to convert large amounts of forage into milk Harvesting much of that forage herself in the form of pasture, she has provided an extremely economical production system With the need for more intensive management of both the cow and the land, several points must be considered carefully in deciding how forage is to be supplied during the summer months

Crops which grow on most permanent pasture are frequently best harvested by grazing However, these pasture forages usually grow poorly or not at all during the hot weather of midsummer Supplemental feed is necessary in the form of other forages or concentrates

Annual grasses such as sudangrass or millets are frequently used to supply forage in summer. Improved pastures have been developed by fertility and management practices and the use of different forage species. When more luxuriant growth is obtained, there is considerable wastage in grazing from trampling and selective eating. As much as 25 to 30 per cent of a pasture crop may be lost in this manner.

Figure 13.2. Grazing on improved pasture is an economical method of providing forage to the dairy herd during the forage growing season. Courtesy The American Jersey Cattle Club.

Intensive grazing. Many management procedures have been devised to eliminate this waste by more intensive grazing. Rotational grazing, in which the pasture is divided into a number of lots and each one grazed for one to several days while the other lots recover from grazing, is one method. This not only reduces wastage to some extent but, even more important, it provides fresh rapidly growing feed over a longer period. Even with this grazing system, in much of the country the pasture program requires summer annuals to assure forage in midsummer.

A more intensive grazing system, called "strip grazing," is also practiced. This consists of allowing the cattle access to only as much of a pasture crop as they will clean up in a day, and putting them in a new area each day. The labor and fencing requirement for such a practice is high, although electric fencing can usually be used to good advan-

Figure 13 3 Dry lot feeding of fresh or preserved forages is a desirable method of providing roughage during the summer in many intensive dairy operations Courtesy The Holstein Friesian Association of America

An accurate analysis of the summer forage program would increase efficiency on many dairy farms

Production and feed records Knowing the actual production and feed consumption in a herd is one of the most important management functions, and one frequently neglected With feed from several sources, hay, silage, pasture, and grain, it is not always easy to keep accurate records continuously Systems for providing workable records are discussed in Chapter 7

Cow Pools

An interesting development in the milk production industry has been the formation of cow pools This is a system in which several herds are brought together in one location and under one management Typically, a system of charges is established for housing care and management of the herd The owner receives all income from the herd in excess of these charges The greatest advantage to herd owners in this program

tage. There is considerably less wastage although there may be damage to the crop owing to trampling on moist soil. This system also requires a variety of pasture crops if roughage needs are to be met throughout the season by grazing.

Green chopping or zero grazing. Chopping forage material in the field once or twice daily and hauling it to cows for dry-lot feeding has been practiced by many dairymen. This procedure has the advantages of doing away with fencing and with moving the cows to and from pasture. Feed requirements for maintenance are reduced when cows do not have the work of walking and grazing Shade and water can be provided easily.

Zero grazing also creates some problems. Weather and soil conditions frequently make it extremely difficult to provide forage each day. Machinery must be kept in operating condition all the time. Much labor is involved in providing green chop, and the labor must be continuously available. Keeping a forage crop in the right stage of maturity for each day's harvest is difficult. These problems have caused many dairymen to decide against green chopping as the method of supplying forage to their herds.

Preserved forage. In areas where dairy operations are extremely intensive, no attempt is made to supply fresh forage. Cows are maintained on harvested forage throughout the summer as well as winter months. In some areas, this allows the operation of dairy units in population centers several miles from where forage is grown. It also works well on farms where high crop yields in terms of animal product can be obtained at a cheaper unit cost than by harvesting by grazing or green chop.

Choosing the best summer forage program. Dairy cattle have demonstrated that they can perform well under any of the programs discussed here, providing their nutritive requirements are supplied. The decision, therefore, is not what is best for the cow nearly as much as what are the economies involved In determining which practice or combination of practices to follow, the dairyman should carefully budget the costs of land, labor, fencing, establishing crop stands, and so forth, against the expected yield of nutrients (energy especially) from each practice The effect on other operating costs should also be considered. For example, a harvesting system costing slightly more per unit but yielding considerably more units may be the most economical if it removes the need for providing nutrients from other sources, which may be a significant added expense.

Where large amounts of land are adapted to pasture but unsuited to harvested crops, grazing to the extent allowed by this land is the logical answer.

owner may retain an option to repurchase them at market value as they reach maturity. In this system, the identity of the heifer is maintained and the milking herd owner has more knowledge of the animals he is introducing as replacements. This applies both to the inheritance of the heifers and their health and disease background.

ORIGINATING A MILK PRODUCING BUSINESS

Traditionally, the operator of a commercial milk-producing business has been one who obtained a large equity in the necessary cattle, land, buildings, and equipment. Owner-operated organization has been most common. Increased capital requirements of modern establishments make it difficult for the average individual to accumulate sufficient capital for total ownership. However, ample opportunity exists for the well-qualified individual to establish himself in the dairy business. In addition to concentrating on the accumulation of capital, the person interested in such a career needs a great deal of knowledge and experience. He must be well-trained in the business and marketing aspects of the industry as well as in the techniques of handling cows.

Demonstration of management ability and an understanding of cattle from working with an established herd, and a reputation for complete honesty and integrity will create public confidence in an individual. Once a satisfactory reputation is established, a sound financial structure for the proposed dairy operation should be developed. Presentation of a realistic plan to bankers or other credit organizations should result in adequate loans to qualified individuals. Of course, some equity by the individual will be necessary.

Establishing a dairy business in which intensive management of the herd is emphasized and most of the feed purchased may be desirable. If a major portion of feed is purchased, the investment required for land and machinery is much less, frequently only one-half of that needed when all feed is produced on the dairy farm.

Traditionally, most operators of dairy farms have attempted to raise as much of the feed for the herd as possible. This is an excellent practice in many operations. A careful look should be taken at this system. However, managing a dairy herd for efficient production, and doing an adequate job of feed raising, both require a high degree of specialized training and management skills. Concentration on one of these areas can be a full time job and may provide greater return than working in both.

Until recently, feeds, particularly forages of satisfactory quality, have been relatively unavailable in some regions. Modern transportation systems have to a considerable degree eliminated this situation. Buying

occurs when an improvement in market from Grade B to Grade A is achieved. An opportunity is also provided for the owner of a small herd to take advantage of some of the efficiencies of a large operation, in terms of use of equipment and the purchase of supplies in volume.

After the initial advantages of better market and volume purchases are achieved, investment in a dairy herd in a cow pool becomes a matter of choice between it and all of the other investment opportunities open to the owner of capital. As a result, ownership of cows in a cow pool tends to include a wide range of people, other than dairymen, who are interested in a good investment opportunity.

Operation of a cow pool provides one way of establishing a milk producing business using investment capital from a number of herd owners.

The need for top management and sound financial structure is of particular importance in the operation of a cow pool. To be successful, production must be maintained at a level which will pay the fixed charges and provide a suitable return to the owner of the cows, or the herd owners will soon lose interest.

Calves from a cow pool are usually raised by the herd owners, or by other farmers who make a business of raising them on contract or by direct purchase of the calves and sale of heifers at freshening.

Raising Heifers as a Business

With the advent of more intensive management of milking herds and the milking of large numbers of cattle in one operation, many herd managers find themselves fully occupied without the problem of raising replacements. The need for large numbers of good-quality replacements remains just as critical in these herds This situation has resulted in an opportunity to develop a business of raising herd replacements.

The principles of management and feeding are the same as for cattle raised within the herd. The profit available from such a venture depends upon the costs involved and the market value of heifers at freshening time. While there are considerable variations in the market value of cattle in different years and seasons within years, the market value of heifers ready to freshen averages remarkably close to the sum of the value of the calf at birth and the costs involved in raising her to calving age. This means that the person with feed, labor, and buildings for which he is seeking a market or use can frequently find a good one in raising dairy heifers.

In some instances, heifers are raised on the basis of contract between the parties involved. In other cases, the person raising the heifers purchases them as calves from the owner of the milking herd. The herd

14 Marketing Milk and Dairy Products

IN our present economy, the marketing of milk and dairy products is handled to a large extent by specialists. However, a successful milk producer must understand the characteristics of milk markets and the factors affecting them if he is to take full advantage of the opportunities available to him. In addition, many producers find themselves involved as members or directors in marketing co-operatives, which have considerable influence in marketing policy and conditions. Marketing dairy products is a complex and detailed subject making up an entire college course. A summary of some of the factors involved is presented here.

FOOD PRODUCTS FROM MILK

The characteristics of milk and its products have a great influence on conditions under which they find a market. The following discussion indudes the unique properties of the several products, which influence marketing procedures either at wholesale, retail, or both.

Fluid Milk

Fluid milk on the farm is a highly perishable product and must be moved to the place where it is to be processed quickly. The use of bulk tanks for storing milk on the farm has lengthened the possible time before milk must be delivered to a plant. However, two days is the maximum storage time in most areas. Milk is a bulky product with a relatively low value per unit weight. This makes it costly to transport over long distances. The necessity for keeping milk cold during transportation adds to the costs. For these reasons, most milk is processed within 200 to 300 miles of where it is produced. Much of it is moved even shorter distances for processing.

This applies to milk as it moves from the farm to the processor regardless of how the processor uses it. Farm-separated cream has similar characteristics except that it has a higher unit value.

feeds by specific standards can have definite advantages over utilizing forage of varying quality produced on the average farm

Financing for feed in this program can be handled on a short time working basis rather than as investment capital A well managed dairy enterprise can be organized and operated on this basis as well as are other businesses in our economy

Whatever the method used, the young operator should recognize that a period of several years is usually required to acquire the experience and management ability needed to establish a successful dairy enterprise

FURTHER READING

U S Public Health Service, *Milk Ordinance and Code*, Revision of Public Health Bulletin No 220 Washington D C U S Government Printing Office, 1953

Condensed and Evaporated Whole Milk

These two products are manufactured by removing a major portion of the water from whole milk in a machine called a *vacuum pan*. In this process, milk is heated under reduced atmospheric pressure to allow efficient evaporation of the water and a minimum of heat damage to the product. Condensed milk is further treated by the addition of large amounts of sugar. Both of these products are canned for retail distribution and sale. They have a relatively long storage and shelf life without refrigeration. They are markcted under conditions quite different from those that apply to fresh fluid milk.

Cheese

Cheese is made by exposing milk to specific bacterial fermentation, or treatment with enzymes, or both, to coagulate some of the proteins. There are very specific procedures for each type of cheese produced. The manufacture of most cheeses utilizes whole milk. Whey, made up of water, milk sugar, and some of the protein and minerals of milk, is a by-product. Cottage cheesc and some other similar cheeses are made from skim milk, with whey again being the by-product. Cream is frequently added to cottage cheese before marketing. Most of the whole-milk cheeses have a long storage life when properly handled. Refrigeration is required for storing many of them unless they are given special treatment. Cottage cheese and similar types require constant refrigeration and have a relatively short storage life.

Butter

Butter is made from cream and as marketed consists of about 80 per cent milk fat. The remainder is water, salt, and traces of other substances. Buttermilk, the by-product of butter making, is quite similar to skim milk in composition and properties. When handled properly, and refrigerated, butter has a relatively long storage life. In addition, it has a high unit value.

Skim Milk

This product, which results from the separation of cream, has composition and properties which are the result of removiog milk fat. Normally, it contains less than 0.1 per cent fat. Skim milk is utilized in a number of ways.

Dried skim milk powder. Most skim milk is dried in the processing

The various products which come out of processing plants have wide differences in marketing characteristics, some of which are reflected in the price of milk to the producer

Fluid milk to consumers. Milk packaged for fluid consumption must also be delivered quickly and kept under refrigeration because of its perishable nature Regulations prescribed by local health authorities must be adhered to in the production of milk for fluid use There are also regulations concerning the production of milk specifically for manufactured products, but they are usually less stringent The necessity of moving fluid milk rapidly at all points in the distribution system requires that supply be closely tailored to demand Since storage of a reserve is not possible, other means must be used to assure that the supply will be equal to the demand Adherence to regulations of health authorities and keeping a constant adequate flow of milk available have resulted in somewhat higher prices paid to producers of milk used for fluid consumption than to those of milk for other purposes Traditionally, distributors have operated mostly within cities and nearby suburbs There is a growing tendency for expansion of the distribution area of large processors to include points many miles from the processing plant

Cream

Cream is made by concentrating the fat portion of milk in skim milk This is accomplished by passing milk through a cream separator. A separator is a machine which subjects milk to a high centrifugal force, dividing the lighter and heavier fractions There are two delivery spouts from a separator Skim milk (the heavy fraction) is delivered by one, and milk fat with part of the skim milk through the other

In commerce, cream containing 40 per cent fat is a common product Whipping cream contains about 40 per cent fat Coffee or table cream contains about 18 to 20 per cent fat. "Half and half," a product of fairly recent introduction, contains 12 per cent fat.

Some cream is sold for direct fluid consumption Only limted amounts are used this way It has marketing characteristics similar to those of fluid milk. The major uses of cream are in the manufacture of ice cream and butter Cream for these purposes is obtained from separation of milk in processing plants, or from farm separated cream For the best-quality products, cream, because it is perishable, must be treated as carefully as fluid milk Cream for some purposes can be stored for considerable periods by methods which include the addition of sugar and freezing Skim milk is always a second product from the manufacture of cream and will be given further consideration

DEVELOPMENT OF DAIRY MARKETING AND PROCESSING

When dairying first became a specialty, marketing was accomplished by direct producer-consumer contact, with little or no processing involved. Price and conditions of sale were individually negotiated. This system was satisfactory as long as the dairy herds were located close to the consumers. However, increasing specialization, consumer demand for extensive processing, health regulations, and the handling of larger volumes, especially in big cities, developed a need for processors and distributors. Pasteurization, complicated packaging, homogenization, use of many variations of milk, and the necessity for efficient use of expensive equipment, refrigeration, and power supplies, made the processor-distributor increasingly important. The use of machinery and the need for highly skilled personnel have made processing plants almost the only place where manufactured dairy products are made.

Modern distribution methods, increasing costs of home delivery, particularly the labor involved, and the development of products with longer storage life, have increased the importance of retail stores as outlets in milk marketing. This has further removed the producer from the consumer. Every indication points to an increasing participation of people with specialized interests and skills in the marketing and distribution of milk.

Developments in Marketing Fluid Milk

Producer-distributors of milk still exist in most markets, but usually account for only a small percentage of the total volume. As specialization developed it became the practice for a processor or distributor to contract for milk from dairy farmers in the area of his plant. This was usually purchased on a given price per unit for all the milk delivered. There is only slight variation from day to day in the amount of milk that the customers of a processor use. However, there has been a history of seasonal variation in milk supplies of producers. During seasons of high supply the processor had several alternatives open to him. He could cut off part of his producers entirely, he could find a market, usually in manufactured products, for his extra milk, or he could impose a partial reduction in the milk received from each producer. If he found a market for the extra milk at a lower price, he either had to pass the price reduction back to the producers, or set his original year-round price low enough to account for his low-priced sales. If the processor refused milk from producers, they had to find another outlet, nearly always at reduced prices.

This is a very simplified presentation of some of the problems which

plant. The resulting powder is sold for: (1) table use after reconstituting, that is, after replacing the water; (2) industrial use in baking and the mass preparation of food, (3) animal feed. Dried skim milk has a relatively long storage life and is marketed accordingly.

Condensed skim milk. This product is made by removing water from skim milk in a vacuum pan. It is seldom marketed to individual consumers. Most of it is used in the manufacture of ice cream and other foods. For some of these purposes it may have sugar added. This product is usually used in manufacturing fairly soon after it is made.

Special Products

A number of special products are made from milk which usually are marketed strictly on a local basis. Buttermilk, yoghurt, sour cream, and similar fermented products are included here. They may be important in local markets, but have fairly short storage life and are marketed to the consumer much like fluid milk. Considerable amounts of skim milk are used in the manufacture of cottage cheese.

Concentrated Milks—Fresh, Frozen, or Canned

There has been considerable research on concentrating milk by removing water in such a way that the reconstituted product resembles fresh milk more closely than the present evaporated or condensed milk. An advantage of this type of product lies in much reduced shipping costs. As yet these products have not been marketed on anything but a very small scale. As more skill develops in the techniques required to make good-quality products, and as marketing procedures are developed, they may become a factor in milk marketing. They are designed for uses now filled by fluid milk. Some of them, for example frozen or canned concentrate, would be expected to have a longer storage life than fresh milk. Concentration also gives them a greater unit value, facilitating transportation over greater distances.

Sterile milk. Processes have been developed for the sterilizing and canning of whole milk. The purpose is to provide a longer storage life. Currently only limited amounts are being processed in this way. Most of it is marketed to the armed forces, and in areas where it is impossible to obtain regular fluid milk.

Industrial uses of milk. Fractions of milk are used in some industrial applications. Glue, paints, and certain plastics are examples. Current uses of milk for these purposes are small and they are not a major factor in market demand.

pendent manufacturer may also process surplus milk. Ice cream, using cream and condensed skim milk, is the product of choice in most population centers, because of its relatively greater return. Remaining milk usually is processed into butter and powdered milk. There is also considerable cottage cheese made from surplus milk in many fluid markets. This utilizes skim milk resulting from tbe cream consumed in fluid sales and ice cream.

In many areas of the country, dairying is a highly efficient enterprise due to climate, type of land and other factors. However, in several of these locations there are limited populations providing a small market for fluid milk. It is in these areas that the majority of manufactured dairy products are made. Depending upon the type of plants existing in an area, milk may be processed into cheese, condensed or evaporated milk, or butter and skim milk powder. Commercial processing plants are located in these areas to be near a supply of milk for this manufacturing.

Much butter and some cheese has been manufactured by local producer co-operatives in the Midwest. These were formed frequently on a community basis to provide a better market for milk. There has been a trend for several years away from this type of operation. The development of efficient machinery of high capacity, as well as improved transportation facilities, has made large centrally located processing plants much more efficient markets for milk.

Another change which has occurred is the relative value of fat. Until recently, there has been continuous demand for more fats than could be supplied by our agriculture. Following World War II, increased production and use of vegetable fats, and replacement of soaps by detergents, has changed this picture. Not many years ago most of the value of milk was in the fat, and skim milk from butter production had little value. Indeed, where skim milk was produced in a manufacturing plant, it was practically a waste product or was sold at a low price for animal feed.

The availability of the cream separator at a size and price adapting it to individual farms played a large part in the establishment of small co-operative butter plants. Skim milk was available on the farm for feeding calves and swine and only the high-value cream needed to be shipped. As methods have been developed for processing and storing skim milk, especially by drying it, and as there has been greater recognition of its nutritive value, this fraction of the milk has become increasingly important.

To obtain a satisfactory return on milk produced in practically any area, both the fat and skim milk must now be sold. As an aid to this practice, methods have been developed for raising calves with minimum amounts of whole or fresh skim milk. These can be used more cheaply in most areas than by feeding large amounts of milk.

created dissatisfaction among producers, and some instability in markets and available supplies. Marketing co-operatives were formed by producers in many areas following World War I to help solve these problems. More discussion will be devoted to them in a following section. They were of considerable aid in stabilizing markets, but did not solve all problems, and there are some marketing problems which are specific to co-operatives.

Classified pricing was a development which came into prominent use during this period. Under classified pricing the distributor pays the producer on the basis of the use of his milk. Class I, Class II and Class III and surplus milk are terms frequently used. They are not quality designations but apply to the use made of milk. Class I refers to milk sold to the consumer for fluid consumption. It sometimes includes fluid cream. Class II usually refers to milk used for the manufacturing of products bringing fairly high return in the market, for instance, cream and ice cream, or it may refer to all milk used for manufacturing. Class III refers to milk used for the manufactured products which bring a lower return, such as butter, dried milk powder, and so forth. *Surplus milk* refers to milk which is in excess of a specified need defined in each market. It is also used to describe milk produced in excess of a "base" or producer allotment, which will be more thoroughly discussed later. There is considerable variation in the terms used in different markets.

The terms *Grade A* and *Grade B* are frequently encountered in milk marketing While there may be some local variations in their use, "Grade A" nearly always refers to milk produced under conditions which make it acceptable for fluid use in a given market "Grade B" refers to milk produced under conditions which do not make it acceptable for fluid use in the market. There is a growing tendency in many sectors of the dairy industry toward the feeling that all milk should be "Grade A," or acceptable for fluid use.

As a further aid in stabilizing the marketing of fluid milk, state and federal legislation has been passed More attention will be given the operation of milk marketing under this legislation in succeeding sections.

Developments in Marketing Milk for Manufacturing Purposes

In each fluid milk market there is a requirement for facilities to manufacture dairy products. These are necessary to use the milk which is surplus to fluid needs. The greatest need is to use up seasonal surpluses. However, a stable fluid market requires an average of about 15 per cent more milk than is used in an average day, to cover fluctuations in demand This milk ends up in manufactured products. Each processor in a market may have manufacturing facilities, or one or two may handle the surplus milk for all of them. A marketing co-operative or inde-

of fluid milk for a given market. There is a trend toward more uniformity in health regulations, which may be expected to make economic factors even more important in the future.

Most manufactured dairy products are marketed on a national basis. Because of their longer storage life and higher unit value in relation to fluid milk, they can be transported to any part of the country where there is a demand for them. These facts are important in determining the methods used for pricing milk and its products in most markets.

Functioning of Fluid Milk Marketing Co-operatives

Marketing co-operatives have been formed in most major milk markets. Membership is usually composed of milk producers, who finance the co-operative by a small brokerage fee on each unit of product sold through the co-operative. Policy is established by a board of directors elected by and from the membership. It is carried out by a staff employed by the board of directors.

Services of co-operatives include bargaining with distributors on price and conditions of sale for producers' milk, arranging for the transportation of milk to dealers, taking responsibility for continuous supplies to dealers and for disposing of surplus milk, advising and aiding producers in conforming to health regulations, aiding producers in adapting to changes in market demands, and checking on quality and butterfat test of producers' milk. These may be accomplished in several ways.

Bargaining with processors and distributors for price and conditions of sale has been one of the greatest services of co-operatives. Where a high percentage of milk in an area is controlled by a co-operative, it is in a strong bargaining position. When only a relatively small portion of the milk in a market is controlled by a co-operative, or there are large supplies on the fringes of a market, the co-operative is correspondingly weaker in regard to bargaining. To further strengthen their position in the market, some co-operatives operate processing plants, either for manufactured products, fluid milk, or both.

Dairy marketing co-operatives, like other agricultural co-operatives, operate under specific legislation passed by Congress. They are limited in the extent to which they can operate as a monopoly in a given market. Some of them have been the subject of suit by the United States Justice Department under the anti-trust laws and have been required to modify their procedures. This has happened in situations where co-operatives have been accused of close co-ordination of activities with other aspects of the dairy business to reduce competition. Co-operatives have been ordered to limit their business activities in areas where the Justice Department has accused them of controlling a major part of both supply and distribution of milk.

SPECIAL FACTORS INFLUENCING THE MARKETING OF MILK AND DAIRY PRODUCTS

There are a number of characteristics which make the marketing of milk and dairy products unique. Some of them are now discussed.

Position of the Individual Producer in the Market

The individual producer in a milk market has practically no influence on the total supply available for distribution. Even large producers account for only a small fraction of the milk available in a given area. In addition, it is not possible to stop and start production of milk quickly. The perishable nature of milk makes it impossible to stockpile it or to withhold it from the market. Current production must be marketed within a period of one or two days. These characteristics make the problems of marketing milk by the producer different from those of most manufacturing industries. Indeed, they are different than those for many agricultural products.

In a situation of a continuous supply of a product which must be moved immediately, and no influence on the total supply, the individual producer has little bargaining power with processors or distributors

Differences Between Fluid Markets and Markets for Manufactured Products

Milk for fluid markets is nearly always more expensive to produce than that designed expressly for manufacturing purposes. Compliance with regulations established by local health authorities is the major cause of the added expense.

Because of the nature of health regulations, which usually include inspection of all farms shipping to a market by a representative of that market, and the costs involved in complying with them, most fluid markets are local in nature. There are indications of considerable overlapping of some local fluid markets, particularly where large population centers are expanding toward each other. This is noticeable along the Eastern Seaboard of the United States. In this area, pricing of milk and marketing practices are carried out on a local basis, but the level of milk supplies in adjacent areas or markets has a very definite affect on practices in any given market.

Techniques and methods are now available which make possible the shipment of fresh milk for distances of 1,000 miles or more. As a result of this, economic factors are becoming increasingly important, as compared to health regulations, in determining the place of production

basis, provide a financial incentive for high fall production and for lower production in the spring. Base-surplus payment plans and withholding-payback plans are used. There are many variations of these. Basically, under the base-surplus plan the producer is given the blend price, that is, the weighted average of the prices for all classes of milk, the entire year for the amount of milk shipped during a designated period, which is usually the fall. Milk shipped in excess of this amount is paid for as "surplus" at a reduced price. In some markets where there is an abundance of milk in relation to Class I needs, it is extremely difficult to increase the "base" assigned to a farm or establish one on a new farm. In these instances the base plan is used to limit the total supplies in the market as well as to even out the seasonal supply.

The withholding-payback plan involves reducing the amount the producer is paid for milk shipped during the flush period. This money is held in escrow by the co-operative and used to increase the payment for milk to the producer during the season of low production. The producer who has the same level of production in both seasons breaks even. The one who ships more milk during the season of low production than in the flush period increases his income. If his production follows the opposite trend, he loses money.

The perishable nature of milk and the daily consumption of it, coupled with the working habits of our population, creates some unique problems in marketing milk. There is a considerable fluctuation in demand by processors during the week. Most plants do not operate on week-ends. Thus, Thursday is a day of peak demand to provide milk for distribution on Friday and Saturday to supply week-end demand. Monday is also a day of peak operation, and demand may be great or average depending on whether milk was received at the plant on the week-end. In some markets there may be fluctuation in demand by consumers due to a number of factors, such as movements of people, holidays, and so forth.

To maintain a smoothly operating market there is a requirement for about 15 per cent more milk available than is consumed in fluid form on an average day. However, there must be capacity in the market to manufacture or sell to other markets considerably more than the 15 per cent surplus on days of low demand by processors, and also in the season of high supply. Marketing co-operatives usually assume the responsibility for adjusting between this variation in demand and the constant supply. This is an extremely important service to all concerned in the market.

Special problems in marketing milk. The details of milk marketing vary greatly with different areas, and the person who has an active interest in a local market must study the situation there carefully if he is to fully understand it.

Severe competition between dealers can have an undesirable effect on producers. Under conditions of a price war, dealers can be in serious

In reality it is difficult for a co-operative to control the supply of milk from individual producers. The independent operation of each producer is such that either an increase or decrease in price tends to cause him to increase production. In times of rising prices, he increases his production to take advantage of the better opportunity, in the same manner as any other production business would.

When prices fall seriously, if the dairyman is to maintain his established income he has two alternatives. One is to produce the same amount of milk more efficiently, that is, at less cost. The other alternative is to expand production and receive the lesser profit on more units There are limits to the effectiveness of both practices. Some dairymen use the first satisfactorily, but seldom reduce production, so that dairymen who use the second system increase the total milk in a market. There is usually no decrease in production unless some dairymen leave the business. Even then there is only a small decrease since, when a dairyman sells out, most of his cows are purchased by his neighbors. The first alternative, increasing efficiency, frequently takes the form of more production per cow. In this instance, even rather large reductions in numbers of cows in an area is not accompanied by a decrease in the milk supply. This situation is amply demonstrated by the decline in the number of cows in the United States following 1946. From then until 1959, there was a reduction of the cow population amounting to 20 per cent of the 1946 population. There was an increase in production every year until 1959, when it leveled off.

Payment for milk to producers. Members of a co-operative may receive payment for their milk according to several plans. The most common is the *market pool plan.* Under this system, each milk producer who is a member of the co-operative receives the same price per pound for all his milk This is the average price received for all of the milk sold in the area by the co-operative, minus the brokerage charge. Dealers are usually charged for the milk according to the use they make of it.

Another payment plan is called the *handler pool* Here the co-operative pays the milk producer according to the use that the processor makes of his milk. The proportion of the milk in Class I, II, and III is calculated, the appropriate price assigned to them, and a weighted-average price is calculated In this system producers ship their milk to individual handlers, who determine their own prices. This is in contrast to the market pool plan, in which all producers are paid at the same rate.

Seasonal variations in milk production are a serious problem in marketing. The natural physiology of the dairy cow is such that, unless intensive management is practiced in regard to time of breeding and the feeding regimen, there is a large surplus of milk in the spring and a shortage of milk in the fall.

Many co-operatives, in an attempt to level out production on a yearly

GOVERNMENTAL CONTROL OF MILK MARKETING

There are a number of other problems which create unstable market conditions and endanger the supply of milk to an area. In order to aid in solving these problems, governmental controls have been made available. These take two forms, those established by state governments and those established by the federal government.

State Milk Marketing Legislation

A number of states have established regulations controlling the marketing of milk in attempts to stabilize markets and supplies. These regulations have established price control and conditions of sale at both the retail and wholesale level, depending upon the local conditions. In some states, these regulations have existed for a number of years with considerable success. However, fluid-milk markets are determined by population concentrations which often extend across state lines. Also, individual states have very limited control of milk in interstate commerce. For these reasons, state regulations have been inadequate to provide stability in many milk markets. Federal regulations have been required in these instances.

Federal Milk Marketing Orders

Federal Milk Marketing Orders are established and administered by the Secretary of Agriculture under acts of Congress passed in 1933 and 1937. They are designed to stabilize the marketing of milk and assist farmers in negotiating with distributors for the sale of their milk. Orders operate by regulating handlers selling in the designated marketing area. Prices paid to producers are controlled, but there is no direct control of retail prices. Each order is under the direction of an Administrator appointed by the Secretary of Agriculture. He employs a staff of accountants, auditors and technicians to carry out the work of the order. Approximately 80 fluid milk markets scattered throughout the country operate under Federal Milk Marketing Orders.

The pricing of a major portion of the milk sold for fluid use in the United States is either directly or indirectly controlled by Federal Milk Marketing Orders. The price established in an order area usually sets, within a few cents per hundredweight, the price paid by unregulated dealers in adjacent areas.

In general, milk sold at retail within the geographical area covered by an order is under its direct control. Milk sold outside this area is not. Regulations covering the operations of handlers having sales both inside

trouble, and they make every attempt to pass on price reductions to the producer

The demand for fluid milk in a given market is quite constant. Price changes of one or two cents per quart result in very slight changes in consumption Even quite large changes in price are not followed by marked changes in use Therefore, differences in price by dealers in a market do not affect total consumption, but may have a marked affect on the volume handled by individual dealers Competition between retail stores, particularly when dairy products are used as loss leaders, can also have a severe effect on milk markets Smaller dealers and distributors may be seriously injured by the availability of dairy products in stores at prices equal to or below raw material costs

Marketing co-operatives have been of great help to producers in markets where tough retail price competition exists In some areas, price competition among dealers in its many forms has become so serious that governmental control of pricing has been necessary to preserve orderly supplies of milk. This will be discussed more fully in the next section on governmental control of milk marketing

Milk marketing co-operatives have been highly successful in markets where a majority of producers belong to them and in large fluid markets where the milk available is not greatly in excess of Class I needs

Marketing co-operatives have their most serious problems in areas where there is a good fluid market but available supplies are greatly in excess of fluid needs, and a large spread develops between the Class I price and the blend price Dealers not purchasing through the co-operative can buy milk from non member sources at prices above the blend and sell it for Class I use cheaper than the dealers purchasing from the co-operatives, and still have a greater profit The lower priced milk takes some business away from processors buying through the co-operative, and Class I utilization of co-operative milk drops The blend price drops The dealer buying outside the co-operative drops his producer prices with the blend price Now a cycle of lower prices for the producer is started It is usually stopped only with difficulty An example of the situation might be as follows

Co-operative prices	Class I	$5 60
	Manufacturing Milk	$3.30
	Class I utilization	60%
Co-operative blend price		$4 68, less brokerage

A dealer buying independently of the co-operative offers $4.80, or 12 cents above the blend, and he also charges no brokerage If he has a 100 per cent Class I utilization on this milk he has paid 80 cents per 100 pounds, or 2 cents per quart, less for Class I milk than the dealers purchasing through the co-operative

farmers. They do not replace marketing co-operatives, in that they only establish wholesale prices and do not perform other services of co-operatives.

FURTHER READING

Beal, G. M., and H. H. Bakken, *Fluid Milk Marketing*, Madison, Wisconsin: Mimir Publishers, 1956.

Hinds, Max, and William Johnstone, *Dairy Economics Handbook*, Agricultural Handbook No. 138, Washington, D.C.: U.S. Government Printing Office, 1958.

U.S. Department of Agriculture, Agricultural Marketing Service, *Questions and Answers on Federal Milk Marketing Orders*, Agricultural Marketing Service-122, Washington, D.C.: U. S. Government Printing Office, 1959.

U.S. Public Health Service, *Milk Ordinance and Code*, Revision of Public Health Bulletin No. 220, Washington, D.C.: U.S. Government Printing Office, 1953.

and outside the area of an order are specifically set out in each order A producer living at some distance from an order area selling to a handler distributing in the order area is covered by it A producer living within an order area but selling milk to a handler distributing entirely outside this area is not covered by it

Records are obtained and authenticated on the amount and utilization of milk processed by each regulated handler Procedures are established in the order for determining the price of milk utilized for Class I and for manufacturing purposes Producers are paid on the basis of pool prices as previously described Either market-wide or handler pools may be used Under a market-wide pool, producers are paid the uniform or blend price by each handler Handlers having a high Class I utilization pay into the Administrator's Office the difference between their Class I utilization and the blend price Handlers having a low Class I utilization receive from the Administrator's Office the difference between the blend price and the Class I utilization of the handler

The cost of administration of Federal Milk Marketing Orders is paid by an assessment on handlers on each hundredweight of milk processed

Establishing a Federal Milk Marketing Order The Secretary of Agriculture initiates work on establishing a marketing order upon receipt of a petition from farmers in the area Proposed provisions of the order are usually submitted with the petition Public hearings are held where anyone interested may express opinions and present facts and information for consideration A "recommended decision and order" is issued for consideration of those concerned in the market Any changes deemed necessary are made, and a final decision and order are issued This is submitted to dairy farmers for their final decision and vote Two thirds of the farmers voting must approve an order in which pricing is based on a market-wide pool Three fourths must approve an order based on a handler pool Marketing co-operatives may vote for their entire membership in a block Thus, the vote of co-operatives is frequently a decisive factor

Changing Federal Market Orders. Provisions of marketing orders may be changed by amendments following somewhat the same procedure as for establishing an order

Removal of Federal Marketing Orders The provisions of an order may be suspended by the Secretary of Agriculture whenever they are found to interfere with orderly marketing procedure or to have no influence on the market An order must be rescinded when the Secretary of Agriculture determines that 50 per cent of the dairymen delivering 50 per cent of the milk to the market favor its termination

The existence of Federal Milk Marketing Orders in most of the major markets in the country indicates their widespread acceptance by dairy

10. Describe the changes which take place in the developing udder from birth to the start of lactation. What are the factors responsible for these changes?
11. Describe the changes which take place in the udder during a dry period, and up to the start of a new lactation.
12. Give the details of a satisfactory milking procedure.
13 What are the factors to be considered in adjusting a milking machine for proper operation?
14. What are the effects of disease on milk production?

Chapter 3

1. Develop a satisfactory ration for a cow weighing 1,200 pounds, producing 40 pounds of four per cent milk each day.
2. What are the annual requirements in terms of ration ingredients for the above cow, assuming an annual production of 10,500 pounds of four per cent milk, a 60-day dry period, and a calf born 365 days from the start of lactation?
3. Discuss the factors which determine the upper limits of grain feeding which are practical.
4. What nutrients are required by dairy cattle? Which of these must be supplied in the diet?
5. Discuss the functioning of the rumen.
6. What factors determine a suitable ration for dairy cattle?
7. What are the important differences in characteristics between forages and concentrates?
8. What is the importance of fat in the rations of mature cattle?
9. Discuss the factors of importance in determining the quality of a forage for dairy cattle.
10. How is the Total Digestible Nutrient value of a feed determined?
11. How does Total Digestible Nutrients differ from Estimated Net Energy?
12. Define and describe digestible energy.
13. Describe digestible protein. How does it differ from crude protein?
14. Describe the parts of the ruminant stomach.

Chapter 4

1. Describe the functions of the ovaries in reproduction.
2. Describe the function of the testes in reproduction.
3. When in the reproductive cycle is the most effective time to breed a cow? Why?
4. What hormones are essential in reproduction, and what is their function?

QUESTIONS AND PROBLEMS

Chapter 1

1 How is the milk producing industry distributed in the United States?
2 Discuss the trends in total milk production, average production per cow, and numbers of cows in the United States during recent years
3 What are the nutrient contributions of milk and dairy products to the human diet?
4 Discuss the use of meat from the dairy industry in our food pattern
5 Discuss the factors of most importance in the efficient management of a milk producing business
6 Describe the place of the dairy cow in a situation of rapidly growing population and more intense competition for food between man and animals
7 Discuss factors which have contributed to the development of the dairy industry from one of producer-consumer relationship to one employing people trained in many specialties
8 How much milk would be needed by an average adult to meet his major nutrient requirements? What nutrients would be lacking in an all milk diet?

Chapter 2

1 What is the importance of the hormone oxytocin in milk production?
2 Discuss the problem of feed flavors in milk
3 Describe the difference between true secretion and filtration in the formation of milk in the udder Which constituents of milk are derived from each process?
4 What are the major differences between colostrum and normal milk?
5 How does the lymph system function in milk production?
6 Discuss the location and importance of the circulation of blood in milk production
7 Describe by words or simple diagram the structures in the udder involved in the secretion and storage of milk.
8 Discuss the action of a milking machine in removing milk from the udder
9 Discuss the factors which control the level of milk production by individual cows

4. What are the management procedures which are helpful in preventing disease in the young calf?
5. Discuss the factors which must be considered in establishing the cost of raising a heifer.
6. Discuss the advantages and disadvantages of raising a calf using a milk replacer and calf starter in comparison with using whole milk.
7. What is the value of cud inoculations for young calves?
8. Under what circumstances might the raising of calves for veal be a profitable enterprise?

Chapter 7

1. Why is production testing important in a milk producing enterprise?
2. What are the major differences between standard DHIA records and Owner-Sampler records?
3. What are the advantages to the herd owner of participating in the DHIA program?
4. To what uses are production records put by the purebred associations?
5. What information, in addition to milk and fat production, is available to the herd owner whose DHIA records are processed by electronic machines?
6. Who are the sponsors of the Co-operative Dairy Herd Improvement testing programs?
7. What group or organization actually supervises the conduct of the various production testing programs?

Chapter 8

1. Who is responsible for the establishment of type standards for purebred dairy cattle?
2. Discuss the correlation between dairy cattle type and milk production.
3. What benefits accrue to individual dairymen and to the industry from dairy cattle shows?
4. Why is an understanding of the standards of type in dairy cattle important to the operator of a dairy herd?
5. What are the advantages of type classification in a purebred herd?
6. Does a low correlation between type and production indicate that a consideration of type is of no value in a commercial dairy herd? Why?

Chapter 9

1. Why is the selection of the sire or sires to be used in a dairy herd of particular importance?

5. Describe the organs of the reproductive tract of the cow and indicate the functions of each.
6. Describe the organs of the reproductive tract of the bull and indicate the functions of each.
7. What is a freemartin?
8. Why is cryptorchidism a serious defect in dairy animals?
9. Discuss the dysfunctions of the ovary and its parts which cause lowered fertility in cattle.
10. What are the characteristics of the diseases which affect reproduction in cattle?
11. Discuss the influence of nutrition on the reproductive performance of dairy cattle.
12. To what degree is fertility or sterility inherited?
13. Discuss the factors determining the optimum time to start reproduction activity in dairy cattle.
14. Discuss the techniques involved in detecting heat in dairy cattle.
15. Describe the care which should be given the cow at the time of calving.
18. What are the important management procedures to be considered in maintaining a high reproduction efficiency in a dairy herd?

Chapter 5

1. Outline the reasons for the growth in the use of artificial insemination of dairy cattle in the United States
2. Describe briefly how bull semen is evaluated for use in artificial insemination
3. What are the functions and characteristics of a good semen diluter?
4. How are accurate records of parentage maintained in the artificial insemination of dairy cattle?
5 Describe the usual technique used in the artificial insemination of a dairy cow.
6. What are the conditions under which semen is transported and stored for use in artificial insemination of cattle?

Chapter 6

1. Outline a feeding program for a heifer calf from birth to six months of age, giving the daily allowances of each feed ingredient.
2. Discuss the use of forages for feeding heifers from six months to calviog age
3. What are the benefits of including aotibiotics in the diet of young calves?

7. What are the important procedures in controlling or preventing parasites in dairy cattle?
8. What treatments are recommended for internal parasites in dairy cattle?
9. What precautions are necessary in treating lactating cows, from which milk is sold, for diseases or parasites?

Chapter 11

1. What are the principal needs or requirements upon which the design of housing for dairy cattle should be based?
2. What are the differences between loose housing and stanchion barns for dairy cows?
3. What mechanical devices are available for handling silage and concentrates fed to dairy cattle?
4. What are the advantages of milking cows in a well-designed milking parlor as compared with a stanchion barn?
5. Discuss the problem of feeding concentrates to cows in a milking parlor.
6. What are the factors which determine whether the use of a particular piece of labor-saving equipment will be economically sound in a given dairy herd?

Chapter 12

1. What are the objectives and functions of the purebred dairy cattle industry?
2. Discuss the services provided a purebred breeder by the breed associations.
3. Describe the characteristics of one of the major dairy cattle breeds, including background, appearance of the animals, milk, usefulness for beef, name and location of the breed organization, and name of the breed publication.
4. Discuss the opportunities available for merchandising purebred dairy cattle.
5. What factors would you include in choosing a breed of dairy cattle for your herd?

Chapter 13

1. Discuss the procedures necessary to produce high-quality milk.
2. Discuss the conditions which are important in determining the optimum size of a dairy herd for a given operation.
3. What can be done to control undesirable odors and flavors in milk?

2 How are inherited characteristics transmitted from parents to offspring?
3 Describe how milk production in dairy cattle is thought to be inherited
4 What is *repeatability* as used in animal breeding? What is its usefulness in selecting cattle for breeding?
5 What is heritability? What is its usefulness in selecting cattle for breeding?
6 Discuss the causes of differences between the levels of production in dairy herds
7 List and discuss characteristics of economic importance which are inherited to a significant degree
8 Discuss the inheritance of undesirable characteristics and their importance in selection.
9 Discuss the obtaining and evaluation of information on the progeny of a bull
10 Discuss the factors which are of importance in evaluating a pedigree when choosing dairy animal for breeding purposes
11 Why is a knowledge of stablemate average or contemporary herd average important in evaluating the performance of dairy cows?
12. Discuss the use of indexes in evaluating bulls
13 Discuss the use of breeding systems for dairy cattle which involve mating animals more closely related than the average
14 Discuss the use of breeding systems for dairy cattle which involve mating animals less closely related than the average
15 Describe how you would organize a breeding and selection program in a dairy herd under your management
16 Describe a program for selecting young bulls for artificial insemination

Chapter 10

1 What is involved in a good program of disease prevention with dairy cattle?
2 How do the federal and state governments participate in eradication programs for certain diseases?
3 Discuss the cause, symptoms, prevention, and treatment of mastitis (Any other disease may be substituted for mastitis in this question)
4 Discuss the problem of poisonous plants for dairy cattle
5 What mineral elements are poisonous to dairy cattle, and what precautions are helpful in preventing trouble with them?
6 What major diseases or disorders of dairy cows are physiological in nature? How is each of them treated or prevented?

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4. What are the federal regulations in regard to residues of feed additives, chemicals, or medicines in milk?
5 Discuss the relative merits of different methods of providing forage to the dairy herd during the summer months.
6. Outline a system of accounting for the costs involved in operating a dairy herd, and the income from it, so that an accurate financial picture is available.
7. Outline a set of reasonable goals of labor efficiency and production levels for a profitable milk-producing operation.
8. What is the potential for intensively operated dairy herds which depend on sources outside their own organization for feed and other services?

Chapter 14

1. What characteristics of milk create marketing problems which differ from those of most agricultural products?
2. Describe the properties of the major products made from milk.
3. Discuss the bargaining strength of the individual milk producer in establishing a price and conditions of sale for his product.
4. Describe classified pricing of milk.
5. Outline the services which are performed by most milk marketing co-operatives.
6. Why is some surplus milk needed at all times in a fluid market?
7. What difficulties arise when the Class I price charged by a milk-marketing co-operative is considerably higher than the blend price?
8. What are the limitations on legislation by states in controlling the marketing of milk in a given area?
9. What changes have taken place in the relative value of skim milk and milk fat? Why?
10. What are the purposes and functions of Federal Milk Marketing Orders?
11. By what mechanisms are Federal Milk Marketing Orders established or removed in a given market area?
12. Discuss the services performed by a milk-marketing co-operative which are important in a market covered by a Federal Milk Marketing Order.